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THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE IV. VOL. IV.

JANUARY—DECEMBER, 1897.

J C Branner

THE

GEOLOGICAL MAGAZINE:

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCXCI TO CCCCII.

EDITED BY

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NEW SERIES. DECADE IV. VOL. IV.
JANUARY—DECEMBER, 1897.

LONDON:
MESSRS. DULAU & CO., 37, SOHO SQUARE.
F. SAVY, 77, BOULEVART ST.-GERMAIN, PARIS.
1897.

st

HERTFORD:
PRINTED BY STEPHEN AUSTIN AND SONS.

210760

LIST OF PLATES.

PLATE		FACING PAGE
I.	*Acanthoteuthis speciosa*, Münster	1
II.	The Old Pump, Cultra, Co. Down	62
III.	High Stacks, Flamborough Head	109
IV.	The Whin Sill at Cullernose, Northumberland	109
V.	*Stereosternum tumidum*, Cope	145
VI.	*Acanthonautilus bispinosus*, A. H. Foord	149
VII.	Portrait of Dr. G. M. Dawson	193
VIII.	*Estheriina*, gen. nov.	195
IX.	Restored Skeleton of *Æpyornis Hildebrandti*, Burckhardt	241
X.	South American and other Estheriæ	289
XI.	Fossil Entomostraca from South America	289
XII.	*Ceraterpeton Galvani*, Huxley	294
XIII.	Stem of new Fossil Cycad, *Cycadeoidea gigantea*, Seward	314
XIV.	*Cycadeoidea gigantea*	314
XV.	A new Silurian Crinoid from Melbourne, Victoria	338
XVI.	Junction of amygdaloid basalt with shales and limestones, near Kinghorn, Fife	370
XVII.	Views of Dùn Beag and Dùn Mòr, Sanday	370
VIII.	Portrait of Harry Page Woodward	385
XIX.	Skull of Male of *Protoceras celer*, Marsh	433
XX.	Portrait of the Rev. P. B. Brodie	481
XXI.	Map of the Pleistocene Geology of Western New York	529

T OF ILLUSTRATIONS IN THE TEXT.

PAGE

s antiqua, Pearce 3
istrict in which the Nino-Owari Earthquake originated 24
" " " " " 26
vert north of Lambert Hill, Hucknall Torkard 50
Cutting through Normanton Hills 53
east of Stocking Farm, near Leicester 55
empanum, Matthew, n.sp. 70
rwelton, Northamptonshire 100
f Hill Farm, Radstone, Northamptonshire 103
arry, Zinal, Canton Valais 111
recubariensis, Crema, sp. 118
r. Bowerbank 135
s of *Æpyornis* 243
yornis Hildebrandti, Burckhardt 248
rchardii, Dewitz 252
ata at Handley's Pit, Lincoln 254
intumescens, Beyr., and *Tornoceras simplex*, Von Buch . . . 281
xion, J. Hall 282
ohylensis and *Glyphioceras Hispanicum*, Foord and Crick . . . 283
lolobus, J. Phill., and *Agathiceras Suessii*, Gem. 284
o show the Formation of Terraced Slopes 302
Cycadeoidea gigantea, Seward 319
Neilston, Renfrewshire 336
mor D'Orbigny 413
inoceras mirabile, Marsh 434
rotoceras celer, Marsh 438
by spinny, north-west of Thorpe Limekiln, Norwich 490
Burlingham St. Mary, near Norwich 492
at Poringland, Norfolk 493
alk-pit, Claydon 494
re opposite Carrigaghalia 507
ffs, west side of Tramore Bay 508
wtown Cove 510
late of *Ceratodus Kannemeyeri* 544
ults to illustrate Mr. Lake's paper 545
" " 546
" " 547

[illegible] Woodward [illegible] West Newm

[illegible] Monsters.

[illegible]

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. I.—JANUARY, 1897.

ORIGINAL ARTICLES.

I.—On an example of *Acanthoteuthis speciosa*, Münster, from the Lithographic Stone, Eichstädt, Bavaria.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

(PLATE I.)

The genus *Acanthoteuthis* was founded by R. Wagner[1] and G. Münster upon small hooklets, sometimes isolated, sometimes associated with more or less complete remains of the animal, which are found in the Lithographic Stone of Bavaria. Münster characterized three species chiefly upon the form of these hooklets, viz., *A. speciosa*, *A. Férussacii*, and *A. Lichtensteinii*, and noticed the existence of a fourth. Subsequently Münster[2] referred to this genus also a number of forms based principally upon the shape of the body and upon the form of the internal shell, but most of these were afterwards separated by A. Wagner[3] as a new genus (*Plesioteuthis*). The genus *Acanthoteuthis* is therefore restricted to such forms as Münster described chiefly upon the form of the hooks. In two specimens of *A. speciosa* Münster says the mantle is preserved, and in it "the broad sword-like pen, devoid of any distinct ridges, is visible" (op. cit., Heft i, p. 94); and, in both of these, "hooks are to be seen near the upper or cephalic end, perfectly similar to those figured in plate ix"; but, writing at a later date (op. cit., Heft vii, p. 55), he says he is not certain what kind of mantle or pen might have belonged to this species. Münster's type and only specimen of *A. Férussacii* exhibits an elongated mantle, rather large head, and short arms (each provided with two rows of hooklets), but Münster says he had no knowledge of the pen of this species. The specimen described below is referred to Münster's *A. speciosa* on account of the shape of the hooklets of its arms.

In his "Handbuch der Palaeontologie" (vol. ii, p. 520, fig. 714), Prof. Dr. K. A. v. Zittel figures an example of *A. speciosa* from the Lithographic Stone of Eichstädt, Bavaria, in which the arms, each bearing two rows of hooks, are attached to an elongated irregularly-shaped body; and at a later date, in his "Grundzüge der Palaeontologie" (p. 443), Professor Zittel also refers to this species the phragmocone and pro-ostracum which he had previously ("Handb. d. Palaeont.," pp. 510–1) assigned to a distinct genus (*Ostracoteuthis*). He states, moreover, that "in the Lithographic Stone of Eichstädt a slab has been lately found which displays the shell and the impression of the animal in association. In the body is an ink-bag; the head is surrounded by ten arms, each furnished with two rows of horny hooks."

---

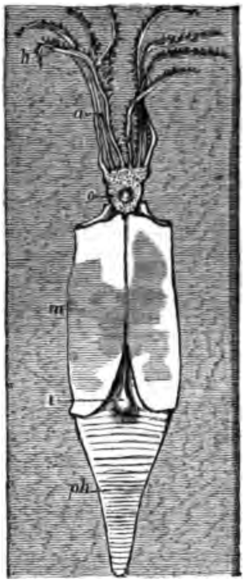
[1] Münster submitted the specimens to R. Wagner, and the letter in which the latter suggested the generic name *Acanthoteuthis* is published by Münster in his "Beiträge zur Petrefacten-kunde," Heft i, 1839, p. 94.

[2] "Beiträge zur Petrefacten-kunde," Heft v, 1842, p. 97; and ibid., Heft vii, 1846, p. 55 et seq.

[3] "Die fossilen Ueberreste von nackten Dintenfischen aus dem Lithographischen Schiefer und dem Lias des süddeutschen Juragebirges": Abhandl. d. k. Akad. d. Wissensch. Berlin, math.-phys. Cl., vol. viii, p. 784.

Since remains of the animal in association with the arms are so seldom found, it seems desirable to place on record a specimen which has recently been acquired by the British Museum from the Lithographic Stone of Eichstädt, Bavaria (Plate I).

The specimen, which is exposed on the surface of a slab, has a total length (including the arms) of about 380 mm. The arms are well shown; the impression of the body is more obscure, but can be fairly well made out in a very oblique light. Seven or eight arms (*a*) can be counted, but they are so disposed upon each other, and some of them so obscured by dendritic markings, that their exact number cannot be ascertained. The longest is fully 120 mm. in length. The hooklets (*g*) are arranged in two rows on each arm; they are small near the head, gradually increase in size along two-thirds of the length of the arm, and become smaller towards the extremity. The hooklets themselves are not preserved, only their impressions. The largest (*h*) is 7·5 mm. long, and the length of its oblique base 2·75 mm. The impressions show that the central portion of each hooklet is depressed so as to leave a ridge on either side, exactly as Münster described in *A. speciosa*. At the base of the arms there is a depression filled with calcite (*b*), indicating the position of the head. Immediately behind the arms there is an oval impression, the smaller end of which is directed backwards; its outline is much more convex, and also more distinct, on the right than on the left side of the specimen; the greater part of the right side of this impression is covered with a thin whitish film, probably the remains of the mantle. Two subparallel obscure grooves extend from the mass of calcite (*b*) across this impression, and pass posteriorly into a triangular depression filled with calcite (*c*); near its anterior end the groove on the right gives off a branch which curves backward and outward, and appears to meet a groove which is continuous with the right side of the triangular depression. From the posterior portion of the oval impression already described the outline of the body gradually expands into a leaf-shaped form, the greater part of which is also covered with a thin whitish film, probably the remains of the mantle. This leaf-shaped portion appears to be formed of two lappets (*e* and *f*), each of which terminates posteriorly in a somewhat indistinct submucronate point, and bears several very shallow grooves, some of which are parallel to its margin. Posterior to the triangular mass of calcite (*c*), there is a well-marked shallow depression with subparallel sides that is traversed by several obscure longitudinal grooves. This possibly represents a portion of the mantle-cavity, for into its posterior part opens the duct of the ink-bag (*d*). The latter is not filled with ink; the posterior portion, i.e. the portion below the dotted line *d*, is hollow and was evidently the "reservoir," while the anterior portion, i.e. the part above the dotted line *d*, has a sponge-like structure and is doubtless the remains of the "pigment-gland." There are no indications of a phragmocone or of an internal shell of any description.



Belemnoteuthis antiqua, Pearce.

a, arms with their hooklets; *o*, remains of the head, with eye; *m*, mantle, with indications of lateral fins; *i*, ink-bag, covered by the pallial integument; *ph*, remains of the phragmocone and of the rudimentary guard.

Now the arms of *Belemnoteuthis*[1] from the Oxford Clay of Christian Malford, Wilts, are furnished with hooks similar to those of *Acanthoteuthis*; and from an examination of one[2] of Münster's specimens, in which small hooklets were associated with a phragmocone,

---

[1] J. Channing Pearce, in Proc. Geol. Soc., vol. iii, 1841–2, p. 593. See also Professor Owen, "A Description of certain Belemnites found, with a great portion of their soft parts, in the Oxford Clay, at Christian Malford, in Wiltshire": Phil. Trans. 1844, pp. 65–85. J. C. Pearce, "On the Fossil Cephalopoda constituting the genus *Belemnoteuthis*, Pearce": London Geol. Journ. 1846, p. 75. W. Cunnington, "On the Fossil Cephalopoda constituting the genus *Belemnoteuthis*, Pearce": London Geol. Journ., May, 1847, p. 95. G. A. Mantell, "Observations on some Belemnites and other Fossil Remains of Cephalopoda in the Oxford Clay near Trowbridge, Wiltshire": Phil. Trans. 1848, pp. 171–181. G. A. Mantell, "Supplementary Observations, etc.": Phil. Trans. 1850, pp. 393–8.

[2] Described in Neues Jahrbuch, 1836, p. 583.

A. Wagner[1] considered that *Acanthoteuthis speciosa* was referable to *Belemnoteuthis*. Professor Huxley[2] concluded his excellent summary of the literature bearing upon this subject as follows:—

"Upon the whole it becomes plain that the *Acanthoteuthes* of Münster, so far as they are known only by hooks and impressions of soft parts, may have been either *Belemnites*, or *Belemnoteuthes*, or *Plesioteuthes*, or may have belonged to the genus *Celæno*; and that, with the evidence before us, it is impossible to say whether *Acanthoteuthis speciosa* and *Férussacii* belong to *Belemnites* or to *Belemnoteuthis*. . . . . Though it is quite possible that either *A. speciosa* or *A. Férussacii* may be really a *Belemnoteuthis*, we have no certain knowledge of the fact" (p. 21).

In his "Handbuch der Palaeontologie" (vol. ii, p. 520) Professor Zittel referred *Acanthoteuthis* to the Octopoda; but in his "Grundzüge der Palaeontologie" (p. 443) he places the genus in the Belemnoteuthidæ and unites with it the phragmocone and pro-ostracum which in his "Handbuch" (vol. ii, pp. 510, 511) he had designated *Ostracoteuthis*.

The specimen described above exhibits no trace of a phragmocone or of a pro-ostracum; but the general form of the body closely resembles—excluding the phragmocone—that of an example of *Belemnoteuthis antiqua* (from the Oxford Clay of Christian Malford) in the British Museum Collection, the lappets at the posterior portion of the body being comparable with the lateral expansions so well shown in that specimen. But in *Belemnoteuthis* the ink-bag is very near the ends of these lateral expansions, whereas in the example of *Acanthoteuthis* described above, it is farther removed from their posterior extremities and is relatively smaller. Still we think the genus *Acanthoteuthis* is properly referred to the Belemnoteuthidæ.

EXPLANATION OF PLATE I.

Figure of *Acanthoteuthis speciosa*, Münster, from the Lithographic Stone of Eichstädt, Bavaria.—*a*, arms. *b*, mass of calcite, probably indicating position of head. *c*, triangular mass of calcite. *d*, ink-bag. *e*, *f*, leaf-shaped lappets. *g*, hooklets of arms. *h*, hooklet enlarged twice natural size.—The figure is a little less than one-half of the natural size.

II.—NOTES ON THE GEOLOGY AND PALÆONTOLOGY OF ARGENTINA.

By FLORENTINO AMEGHINO.[3]

UNTIL a few years ago it was believed that the Territory of Patagonia was of an extremely simple and uniform geological structure; it was supposed that from the Colorado to the Straits of Magellan, and from the Atlantic to the base of the foot-hills of the

---

[1] Op. cit., p. 820.

[2] "On the Structure of the Belemnitidæ; with a description of a more complete Specimen of *Belemnites* than any hitherto known, and an account of a New Genus of Belemnitidæ, *Xiphoteuthis*": Mem. Geol. Surv. United Kingdom, Figures and Descriptions illustrative of British Organic Remains, Monograph ii, 1864.

[3] "Notas sobre Cuestiones de Geología y Paleontología Argentinas": Bol. Inst. Geografico Argentino. vol. xvii, 1896, pp. 87-108. Translated, with Supplementary Observations, by Arthur Smith Woodward.

Andes, it was constituted exclusively by the marine Patagonian Formation, on the age of which the most varied opinions were expressed, although all agreed in referring it to the Tertiary series. This uniformity was interrupted only at intervals by great sheets of basalt which appeared sometimes at the surface, sometimes below the boulder-deposit.

The results of the travels of my brother, Carlos Ameghino, who since the year 1887 has dedicated himself exclusively to the geological and palæontological exploration of the regions of Patagonia, have completely changed this view. These explorations, which have revealed the former existence in the southern extremity of South America of various truly remarkable extinct faunas (as the most illustrious palæontologists of the present day term them), have also demonstrated to us that the Territory of Patagonia is not of so uniform a geological constitution as was said, since it comprises formations of different periods, marine and terrestrial or fluviatile, the latter predominating over the former.

Hitherto he has only published a review of his two first voyages,[1] but he is preparing a detailed description of all his explorations, and although on my part I have given some short notices of his discoveries on different occasions, it has appeared to me useful to attempt a sketch here of the principal geological results obtained.

Little can be said concerning the most ancient sedimentary formations, since these are only visible at certain points where they have been raised by the eruption of large masses of igneous rocks, principally porphyries, which have placed them within range of discovery ; this happens in the central part of the Territory of Chubut, and also in the region of the Deseado and various other places.

SUPPOSED JURASSIC STRATA.

The most ancient sedimentary deposits, which rest immediately upon these eruptive rocks, appear in the upper course of the River Chubut (the tributary Teca) and in the River Genua ; they are shales and red sandstones whose age it is difficult to fix, but it is almost certain that they are not more modern than the Jurassic. As they have not hitherto yielded fossils, nothing more precise can be said.

CRETACEOUS STRATA.

Upon these deposits comes a gigantic formation termed by C. Ameghino the variegated sandstones (*areniscas abigarradas*). "They are composed chiefly of enormous banks of sand, generally of fine grain, with beds of clay and intercalated conglomerates, assuming all the colours and shades imaginable (bright red, purple, ruddy, yellow, green, bronze, etc.)." It occupies the greater part of the course of the River Chubut, a part of the region of the Senguel, and in certain places extends even as far as the Atlantic coast. Its thickness is to be reckoned in hundreds of metres, with its almost horizontal beds slightly inclined to the east and not exhibiting the least unconformity between each other.

---

[1] C. Ameghino, "Exploraciones geologicas en la Patagonia" : Bol. Inst. Geograf. Argent., vol. xi, 1890, pp. 1–46.

Although no fossil remains are yet known from this formation, it is almost certain that it ought to be referred to the Lower or Middle Cretaceous, since the deposits which rest immediately upon it belong to the Upper Cretaceous. In fact, at various points, e.g., on the Senguel, the Deseado, etc., above these variegated sandstones and in concordant stratification, there comes another formation of red sandstones, a little more friable but also of great thickness and containing a considerable quantity of bones of gigantic Dinosaurs. These deposits constitute a vast formation which extends from one end of Patagonia to the other, since it has been observed from the River Negro and the Neuquen to the north, as far as San Julian and Lake Argentina to the south, always with the same characters, everywhere containing remains of Dinosaurs and a remarkable quantity of petrified wood; large complete trunks are continually observed still standing in their natural position.

That this formation is Secondary, is clearly indicated by the Dinosaurs; on the other hand, as its upper beds pass insensibly into another formation, which contains numerous remains of mammals, it cannot be doubted that the sandstones with Dinosaurs belong to the Upper Cretaceous. Mr. Lydekker has given a description of the Dinosaurian remains from this formation preserved in the Museum of La Plata.[1] The species which has left most remains belongs, according to him, to the genus from the Cretaceous of India which he had previously described under the name of *Titanosaurus*, and he terms the Argentine species *Titanosaurus australis*. This conclusion would be indisputably of great importance, but I have my reasons for doubting the generic identity. The other remains are described under the names of *Titanosaurus nanus*, Lyd.; *Argyrosaurus superbus*, Lyd., one of the most gigantic colossal animals which have trodden the earth;[2] and *Microcœlus Patagonicus*, Lyd.

The author observes that until his memoir no representative of this group from the Argentine Republic had been described, but that C. Burmeister had published some preliminary notices of them. These notices, published in the year 1893,[3] are confined to the indication of having met with remains which he supposes to be Dinosaurian—remains whose occurrence in Patagonia had already been reported by Carlos Ameghino.[4] There is also a lack of fairness on the part of the author in not having mentioned that the first notices of the remains of these animals and the determination that they belonged to Dinosaurs, were made by me in various publications, some prior to the foundation of the Museum at La Plata;[1] and the greater part of the remains of *Titanosaurus* figured by the author formed part of my old collection,[2] I not having described them for reasons which need not be mentioned.

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[1] R. Lydekker, "The Dinosaurs of Patagonia": Anal. Mus. La Plata—Pal. Argent., vol. ii, 1894, pt. 1.

[2] The gigantic fore-limb of this animal, which serves as the type of the genus and species, was discovered by Carlos Ameghino, together with the almost complete skeleton in position, at the angle which the River Chico makes with Lake Musters (see F. Ameghino, "Contrib. conoc. mamif. fos. Repub. Argentina," 1889, p. 879; and C. Ameghino, Bol. Inst. Geogr. Argent., vol. xi, 1890, p. 42). Unfortunately, the incompetent persons employed by the Director of the Museum of La Plata for the exhumation of this skeleton only succeeded in extricating one of the limbs, destroying the remainder. The traveller who has occasion to cross this district still descries from a great distance the accumulation of bones destroyed by their vandal expedition.

[3] Revista del Museo de La Plata, vol. iv, 1893, pp. 245–6.

[4] Carlos Ameghino, Bol. Inst. Geogr. Argent., vol. xi, 1890, pp. 42, 44.

However that may be, the presence of the Dinosauria in the formation of red sandstones is of the highest importance, not only from the palæontological point of view, but also because they form a fixed point of departure for the determination of the geological age of the strata resting upon them. These animals are essentially characteristic of Mesozoic times, and with their disappearance in Europe and North America coincides the appearance of the placental mammals, especially of the ungulates. In Patagonia the beds with remains of Dinosaurs pass insensibly into other beds with numerous remains of mammals, particularly of ungulates, which circumstance proves that the red sandstones ought to be referred to the Upper Cretaceous.

THE *PYROTHERIUM* FORMATION.

This brings us to the somewhat more modern deposits, which I have designated with the name of *Pyrotherium Formation* ("Couches à *Pyrotherium*," in Bol. Inst. Geogr. Argent., vol. xv, pp. 603–8), specially intending not to prejudge their geological age; but, according to my first impression, which has not hitherto been in any way modified, they ought to be assigned to the most modern series of the Cretaceous formation.

The mammal-fauna of the *Pyrotherium* beds is one of the greatest interest, and its discovery is destined to elucidate many biological mysteries concerning the origin of the different groups of the class Mammalia.

In 1895 I gave a description of the principal types at that time known,[3] but the later explorations of Carlos Ameghino have already tripled that number. These new discoveries, which enrich palæontology so much, will be described in detail in special works; meanwhile it is of interest here to take a rapid glance at the principal new types.

---

[1] F. Ameghino, Bol. Acad. Nac. de Cienc., vol. viii, 1885, p. 150; and "Contrib. conoc. mamif. fos. Repub. Argent.," 1889, pp. 16, 899, 959. The first remains of Dinosaurs met with in Patagonia, consisting of a complete caudal vertebra and a large rib with the articular head complete, were found in the Neuquen in the year 1882 by Captain Buratowich, and presented by him to the then President of the Republic (General Julio A. Roca), who in his turn presented them to me, and I immediately determined them as belonging to a gigantic Dinosaurian (see *La Nacion*, March 23, 1883). This was the first notice of the former existence of these singular extinct reptiles on the soil of the Argentine Republic.

[2] These remains, from Fort Roca, were presented to me by their discoverer, Señor Don Jorge Rohde, then Captain (now Colonel) of the Military Engineers.

[3] F. Ameghino, "Première Contribution à la Connaissance de la Faune Mammalogique des Couches à *Pyrotherium*": Bol. Inst. Geogr. Argent., vol. xv, 1895, pp. 603 61. In reference to this work, Mr. S. P. Palmer, of the U. S. Department of Agriculture, who is editing a "Nomenclator" of the known genera of mammalia, writes to me that the names *Clorinda* and *Eurygenium*, with which I have designated two extinct mammals from this formation, have been previously employed for other animals. The observation is correct, and it is all the more strange since I had not noticed that the two generic names are recorded in Scudder's "Nomenclator Zoologicus," which I always have at hand. I am thus compelled to change those names, replacing that of *Clorinda* by *Plagiarthrus*, and that of *Eurygenium* by *Eurygeniops*.

The armoured edentates are abundant, but it is evident that the representatives with a ringed carapace, which form the groups of Dasypoda and Peltateloidea, predominate over those with a more or less immovable carapace of the type of the Glyptodontia. Moreover, the latter are only represented by species whose carapace lacks the external sculpture, as in the more modern genera *Neuryurus*, *Pseudoeuryurus*, etc., which, because of this peculiarity, Lydekker (in his recent work on the fossil edentates of Argentina[1]) considers to have been founded on remains of young individuals in which the sculpture has not yet been developed. According to this curious interpretation, the Glyptodonts of the age of *Pyrotherium*, more fortunate than ourselves, remained always young, since the sculpture on the surface of the carapace was never developed. These ancient armadillos, for which I have proposed the name of *Palæopeltis*, differ also from the most recent forms in exhibiting the plates in well-defined transverse rows and to a great extent movable, thus constituting a complete transition between the most modern Glyptodonts with immovable carapace and the armadillos with ringed carapace.

The unarmoured edentates are also numerous and of types resembling those of the Santa Cruz Formation, but generally of much more considerable size. Nevertheless, some forms show very primitive characters, having the molars provided with a well-developed layer of enamel.

With these edentates there are carnivorous animals of a size approximating to that of the largest bears of the present day, but similar to those of the Santa Cruz Formation, and thus belonging also to the group of Sparassodonta, which is distinguished by a mixture of the characters of the polyprotodont Marsupials, the Creodonta, and the placental Carnivora.

The Plagiaulacoidea are also represented by various forms, of which the multituberculate molars exhibit a remarkable transition between the more modern types of the Santa Cruz Formation and those of the Mesozoic formations of Europe and North America.

The rodents are not numerous and appear to approach the Acaremyini of Santa Cruz, but they differ from these in exhibiting five lower molars in function on each side of the mandible, two premolars, and three true molars. Except in the Leporidæ, this is the greatest number of molars met with in mammals of this order: that we are dealing with a primitive character is evident, and this confirms my opinion that the hystricomorphous rodents originated in South America, and not in the Old World as most authors suppose.

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[1] R. Lydekker, "Extinct Edentates of Argentina": Anal. Mus. La Plata—Pal. Argent., vol. iii, 1895, pt. 2.

Notwithstanding the discovery of these animals of small size, the ungulates always maintain the same numerical preponderance, the genera and species being those which I indicated in my preliminary memoir on this fauna, though to the known types there are now added other new ones still more interesting. There has appeared, for example, a whole series of ungulates with mammillated teeth, the classification of which is for the moment very doubtful, but which, at least in the dentition, appear to resemble the Phenacodontidæ of North America; for the present the only notable difference worthy of remark is that the Argentine forms exhibit the dentition in a continuous series.

As I have already suspected previously and pointed out in my work on this fauna, the Proterotheriidæ, such as are known from Santa Cruz and from the deposits of the Parana, do not exist in this formation. The forms which replace them have a complete dentition, presenting also, at least in the shape of the molars, a certain resemblance to the Ancylopoda, those ancient ungulates with hook-shaped toes and the ungual phalanges cleft as in some edentates. Moreover, it happens that the animals which represent the predecessors of the Macraucheniidæ in this formation also exhibit affinities with the Ancylopoda. Among the Typotheriidæ the same resemblance is observed, while some forms apparently of this group, from the structure of the skull and the aspect of the dentition, seem to be the direct forerunners of the modern Hyracoidea of Africa and Asia, one of the few types of existing ungulates which has hitherto appeared completely isolated and without predecessors.

In the representatives of the order of Toxodonts, which are very numerous, these same transitional characters are still more surprising; for while, on the one hand, they pass into the Ancylopoda, on the other they approach the typical Perissodactyla (Stereopterna): this transition is very clearly seen both in the conformation of the dentition and cranium and in the construction of the foot. The transition between the Ancylopoda and the Astrapotheria, at least in the dentition, is equally complete.

These various groups show among themselves less differences than in the Santa Cruz Formation, while by the characters which they exhibit in common in the *Pyrotherium* Formation, they seem to converge towards the Ancylopoda as if this were the original trunk of the ungulates. The only group which appears as yet to constitute an exception is that of the Pyrotheria and its descendants the Proboscidea.

However, perhaps the most important discovery is the finding in these same deposits of remains of monkeys perfectly characterized. We are not, indeed, dealing with types as specialized as the Homunculidæ of the Santa Cruz Formation, but with lower forms which, although they belong indisputably to the group of monkeys, pass into a whole series of animals which have been arranged among the ungulata.

In an article on the fossil monkeys of the Eocene of the Argentine

Republic[1] published in 1891, I arrived at the conclusion that there must have existed a genetic connection between the Typotheriidæ and the monkeys, and that the original stem of the Primates must be sought for in the deposits of the latest periods of the Cretaceous epoch. The discoveries recently made in the *Pyrotherium* Formation prove that that is actually the case. The Primates of this period completely connect the Homunculidæ with the Protypotheriidæ, and at present it seems as if the Homunculidæ, Protypotheriidæ, and Lemuridæ were three divergent branches of one and the same stem.

The Typotheriidæ, finally raised by Zittel to the rank of a suborder (Typotheria), constitute one of the most singular groups of mammals; regarded successively first as ungulates, then as unguiculates, most authors have united them with the Toxodonts, while others have associated them with the rodents and some with the edentates. These curious animals, of which the better-known genera are *Typotherium, Pachyrucos, Protypotherium, Hegetotherium, Icochilas, Trachytheras,* etc., become then a branch diverging from the same stem whence the monkeys arise, a branch which becomes isolated by evolution since the Cretaceous epoch, and the last representatives of which (*Typotherium*) approximate to the Toxodonts through parallel evolution, in the same way that the Proterotheriidæ resemble the horses in the structure of their feet without any very close relationship existing between these two groups.[2]

What is the precise geological epoch to which date back the deposits containing the remains of this singular fauna? In my opinion, as I have indicated above, they are decidedly Cretaceous.

I rely on the fact that these beds with remains of *Pyrotherium* everywhere accompany the red sandstones with remains of Dinosaurs, so that it has not hitherto been possible to separate them in an absolute manner. These sandstones in certain places exhibit nothing but bones of Dinosaurs; in others they show only remains of mammals and smaller reptiles of types not yet determined;[3] while at other points all these remains are shown mixed together, at least to all appearance, always accompanied by a great quantity of silicified wood. In all parts where it has been possible to examine sections, the Cretaceous beds display a concordant stratification from the bottom to the top, without interruption of any kind, so that it is indubitable that the strata with *Pyrotherium* have been continued without interruption into those with Dinosauria. Still more; in some places in the territory of Chubut the variegated sandstones (*areniscas abigarradas*) of the interior extend even as far as the coast of the Atlantic, and are covered in concordant stratification by the same strata with *Pyrotherium*, which are submerged beneath the waters of the ocean, indicating that at that epoch the continent extended much more to the east than at any of the later periods.

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[1] F. Ameghino, "Los Monos fosiles de la Republica Argentina": Revista Argent. Hist. Nat., vol. i, 1891, pp. 383–97, figs. 85–97.

[2] So much interest has been aroused in the fossils of the Patagonian region that the North American Government has despatched an expedition with the object of collecting fossils for the museums of the United States. This expedition is in charge of Messrs. J. B. Hatcher and O. A. Peterson, who are already in Patagonia.

[[3] See supplementary note by the translator, p. 21.]

It is useless to attempt to minimize the clear significance of these facts, saying that the Dinosauria may have lived in Patagonia until a more recent epoch than in other regions of the globe, because the stratigraphical data appear conclusive, and on the other hand the marine fauna leads to absolutely identical results, as is demonstrated by some brief considerations on the Patagonian Formation, which some authors, who are not acquainted with it, attempt to refer to the Miocene, while all who have studied its fauna are agreed in regarding it as Eocene.[1] If the terrestrial formations of Patagonia pass insensibly from the Cretaceous to the Tertiary, we shall see that exactly the same happens with the marine formations of the same region.

THE PATAGONIAN FORMATION.

In the interior of the Territory of Chubut and in northern Patagonia, in the upper course of the River Negro and of the Neuquen, the *Pyrotherium* Formation is found covered by more modern deposits of terrestrial or fresh-water origin, whose fauna is still unknown to us, except some or other remains referable to the Ancylopoda. In the region of the Atlantic coast, on the contrary, the beds with *Pyrotherium* are found below the marine Patagonian Formation. As I have had occasion to point out in another work,[2] this is a fact definitely ascertained and beyond all dispute, since the direct superposition of these two formations has been determined by Carlos Ameghino at more than fifty distinct points, very far from one another.

On the coast the greatest development of the Patagonian Formation is met with to the south of the River Deseado as far as the mouth of the River Santa Cruz, but towards the interior it disappears beneath the thick strata of the Santa Cruz Formation; to the south of the River Santa Cruz it diminishes gradually in thickness, and disappears beneath the sea before reaching the River Coyle, being replaced in the cliffs by the Santa Cruz Formation. The point of its greatest development is found in San Julian, where it attains a thickness of approximately 300 metres.

A most important fact, which must not be forgotten for a moment, is that the true Patagonian Formation of the coast of Patagonia is not to be confounded with the marine formations of the neighbourhood of the Parana. This identification is a grave error which has given rise to many others, since, as I have shown in another work,[3] the marine deposits in this latter locality are indisputably more modern than the deposits with *Ostrea Patagonica* of the coast of Patagonia.

[[1] See supplementary note by the translator, p. 22.]

[2] F. Ameghino, "Première Contrib. Connais. Faune Mammal. Couches à *Pyrotherium*": Bol. Inst. Geogr. Argent., vol. xv, p. 605.

[3] F. Ameghino, "Enumération Synoptique des Espèces de Mammifères Fossiles des Formations Eocènes de Patagonie," p. 5 (Buenos Aires, 1894).

The true Patagonian Formation is undoubtedly Eocene, while its basal or inferior part belongs to the Cretaceous. All the malacologists (D'Orbigny, Sowerby, Philippi, Hupé, Remond de Corbineau, Steinmann) who have studied the shells of this formation, have assigned it to the Eocene, and some to the Upper Cretaceous. All have recognized that the molluscs, even those of the upper beds, belong entirely to extinct species. The fact is, that the Patagonian Formation begins with the Upper Cretaceous, but acquires its great development during the Eocene. The fossiliferous deposits of Quiriquina were at first regarded as Tertiary, and were only assigned to the Cretaceous after there had been discovered in them remains of *Plesiosaurus* (*Cimoliosaurus*) *Chilensis*, of *Ammonites*, and some other Secondary genera.

The late Cretaceous formation of the coast of Chili exhibits absolutely the same aspect and the same lithological characters as the Patagonian Formation. The facies of the fauna is equally the same, since the Cretaceous fauna of Quiriquina only differs from the fauna of the Patagonian Formation by the presence of eight genera (*Ammonites*, *Hamites*, *Baculites*, *Pugnellus*, *Cinulia*, *Pholadomya*, *Monopleura*, *Trigonia*), which are not met with in this latter; while 85 per cent., more or less, of the genera of the Cretaceous formation are also found in the Eocene Patagonian Formation. Moreover, according to Philippi, the best authority on the subject, 20 per cent. of the species of shells of the Cretaceous formation of Algarrobo are likewise species of the Patagonian Formation, and it will be recognized that in Patagonia the marine Cretaceous and Eocene formations pass from one to the other in a gradual and insensible manner.

At different points on the coast of Chili, the Cretaceous beds are covered by a stratum of lignite, which appears to be the same as that worked at Punta Arenas, and which on this side of the Cordillera extends to the north, below the Patagonian Formation, appearing successively at the source of the Coyle, in the neighbourhood of Lake Argentina, in the bay of San Julian, in the River Chico, and at other points.

In the vicinity of Lake Viedma, the lower beds of the Patagonian Formation contain remains of Chondropterygian fishes of Cretaceous species or genera, as *Lamna* (*Otodus*) *Argentina*, Amegh., very close to *Lamna* (*Otodus*) *divaricatus*, Leidy, from the Cretaceous of North America; teeth absolutely similar to those of *Lamna subulata*, Agass., and *Oxyrhina Mantelli*, Agass., from the Cretaceous of Europe,[1] teeth of the Cretaceous genus *Sphenodus*, etc. These remains are found mingled with those of a genus of reptiles of the group of the Plesiosauria (*Polyptychodon Patagonicus*, Amegh.), and another of the family Mosasauridæ (*Liodon Argentinus*, Amegh.[2]), both characteristic of the Cretaceous formations.

Being, then, an indisputable fact that the beds with *Pyrotherium* are anterior to the base of the Patagonian Formation, it is absolutely

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[1] F. Ameghino, "Sobre la Presencia de Vertebrados de Aspecto Mesozoico, etc.": Revista Jardin Zool. Buenos Aires, vol. i, 1893, p. 85.

[2] F. Ameghino, ibid., pp. 79-83.

ble to attribute them to an age more recent than the Upper
ous.
ı my point of view there has hitherto been advanced only
e sufficiently serious argument against the antiquity of the
nian Formation, and it consists in the presence of numerous
s of Cetacea, which (if we except the Zeuglodonts, which are
ıtedly very different animals) only appear in Europe and
America during the Miocene period. But we are dealing
negative proof, the worth of which is only apparent, since
not take into account the fact that these animals appear there
tely developed, without their predecessors being known, and
ly they did not fall from the sky, but went there as emigrants
ther regions. The Cetacea, indeed, are a group of mammals
arose in South America and emigrated to the northern
here, at a comparatively recent geological period, when they
eady acquired all their principal distinctive characters.
enough to glance at the remarkable memoir of Lydekker on
ulls of fossil Cetacea from Chubut[1]—*Physodon Patagonicus,*
Diaphorocetus Poucheti (Mor.), Amegh.,[2] *Prosqualodon aus-*
Lyd., *Argyrocetus Patagonicus,* and *Diochoticus Benedeni* (Mor.),
ı.[3]—which come from Puerto Madryn, from the most modern
f the Patagonian Formation,[4] to perceive that we are dealing
nore primitive and less specialized types than those obtained
the Miocene deposits of Europe and North America; this is
ally very evident in the genera *Argyrodelphis* and *Prosqualodon.*

Lydekker, "Cetacean Skulls from Patagonia": Anal. Mus. La Plata—Pal.
., vol. ii, 1894, pt. 2. As I have observed on another occasion, this volume,
;h it bears the date 1893, appeared more recently, in the month of April,

his work Lydekker designates this Cetacean with two distinct generic names;
heading of the description he employs the name of *Hypocetus*, which is also
ith below the figure on the corresponding plate, while at the end of the
ıtion he uses the name of *Paracetus* in substitution for that of *Mesocetus*, which
o had given to replace this latter, preoccupied for another genus of the same
For my part, I had already replaced the name of *Mesocetus* by that of
orocetus (F. Ameghino, Bol. Acad. Nac. Cienc., vol. xiii, p. 437), placing the
though only in a provisional way, among the Pontoplanodidæ, since my
al object was to give a complete list of all the Tertiary mammals of Pata-
I ought to observe that in reality the genus in question exhibits no relation-
ith the latter group, but with that of the Physeteridæ, as observed by Lydekker,
otwithstanding this, places it with *Physodon* in a new family, which he terms
lontidæ. In accordance with the opinions expressed by Cope, it does not
to me that the presence of teeth in the upper jaw is a character sufficient to
the creation of a new family, since they are also found, though in less number,
esentatives of some species of the allied existing genera (E. D. Cope, "Fourth
oution to the Marine Fauna of the Miocene Period of the United States":
Amer. Phil. Soc., vol. xxxiv, 1895, p. 135).
dekker proposes for this genus the name of *Argyrodelphis* to replace that of
us, under which Moreno had described it, because this latter was already
d by me for another Cetacean. For the same reason I had proposed that of
ius, placing the genus among the Platanistidæ, the same arrangement as
r Lydekker (F. Ameghino, Bol. Acad. Nac. Cienc., vol. xiii, p. 438).
ppears that neither the exact locality nor the precise geological horizon is
whence was obtained the skull described by Lydekker in the same work under
e of *Cetotherium Moreni.*

These primitive characters are recognized by Lydekker himself, who directs attention to them in a very special manner, and thus I need not enter into details.

THE SANTA CRUZ FORMATION.

Above the Patagonian horizon there comes another very distinct formation, consisting of a series of marine and terrestrial deposits, the latter predominating over the former, to the whole of which I have given the name of Santacruzian.[1] Observed first in the interior, where the Patagonian Formation does not appear, it was supposed originally to be much anterior to this, but the subsequent exploration of other regions in which both formations are exhibited superposed has demonstrated the contrary, namely, that the Santa Cruz Formation rests on the Patagonian Formation.[2] The circumstance that the Tertiary deposits of the Parana had been identified with the Patagonian Formation, and the fact that the mammal fauna of the Santa Cruz Formation is evidently of a more ancient aspect than that of the Parana, doubtless contributed to the commission of that error. Unfortunately, the authors who have identified the marine formations of the Parana with the Patagonian Formation have fallen into an error, since the latter is of much older date.

On the Atlantic coast, the Santa Cruz Formation appears to the south of the River Santa Cruz, gradually increasing in thickness in proportion as there is an attenuation of the Patagonian Formation, which finally disappears completely below the sea-level before reaching the River Coyle; between this point and the River Gallegos the maximum thickness of the formation is about 260 metres. The greater part, or the Santacruzian zone properly so-called, which is uppermost and approaches a maximum development of about 200 to 230 metres, is of terrestrial or fresh-water origin; this consists of a series of strata of clay and volcanic detritus, sometimes also with calcareous accumulations, containing almost everywhere numerous remains of extinct mammals, gigantic birds, and also, though in less quantity, remains of reptiles. The mammal fauna is one of the most remarkable claiming the attention of all naturalists occupied with the study of the vertebrata. It is not necessary, and this is obviously not the place, to enter into the details of the subject, for the fauna in question has been the subject of numerous publications, and much more will continually be published upon it.[3] It suffices for me to record that, although this fauna exhibits a very small number of genera in common with that of the Tertiary formations of the Parana and none with the *Pyrotherium* fauna, it presents a much greater general resemblance to the latter, and this proves its great geological antiquity.[1]

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[1] F. Ameghino, "Contrib. Conoc. Mamif. Fos. Repub. Argent.," pp. 16, 17 (Buenos Aires, 1889).

[2] F. Ameghino, "Enum. Synopt. Mamm. Foss. Eoc. Patagonie," pp. 4, 5 (Buenos Aires, 1894).

[3] I cannot, however, omit to mention here a recent discovery which has not yet been published, and which is doubtless destined to rouse great interest in the zoological world. One of the most singular groups of mammals of the Santa Cruz Formation comprises a series of small animals with the dentition somewhat similar to that of the kangaroos of Australia, but still more so to that of the fossil Plagiaulacoidea of the Mesozoic formations of Europe and North America. Those animals, marsupial though not syndactylous like the kangaroos, which I have distributed into the four families of Abderitidæ, Decastidæ, Epanorthidæ, and Garzonidæ, were at this period extremely numerous in genera and species, and in

The base of the Santa Cruz Formation consists of a series of marine deposits of an average thickness of 30 metres, to the whole of which I have given the name of the supra-Patagonian horizon (étage sur patagonien),[2] because it rests directly on the Patagonian Formation. That the deposits just mentioned are of a period distinct from that of the latter formation, I have no doubt; for instead of *Ostrea Patagonica* they contain *Ostrea Bourgeoisi*, which is characteristic of this horizon, and this difference seems to extend likewise to almost the whole of the molluscan fauna.

This horizon, indeed, is of great importance by reason of the quantity of fossil species which it has afforded during the latest explorations. According to the data which Carlos Ameghino has given to me on the collections made there, in addition to *Ostrea Bourgeoisi*, characteristic as I have said of these deposits, there is also a species of the genus *Crenatula* whose known representatives live only in the tropical regions of India and in the Red Sea. The extinct genus *Amatusia* is represented by a species twice as large as that from the Eocene of Chili described by Philippi. There are also species of the genus *Hyanira*, whose representatives are for the most part characteristic of the Cretaceous, and more than a hundred other species of shells, among which are some fresh-water and terrestrial forms. There is likewise a great abundance of fossil crustacea, among which predominates the large *Cancer Patagonicus*, Phil., which itself forms banks of a considerable extent in that formation.

I have placed all these materials in the hands of Dr. H. von Jhering, who will give us the results of his studies. The foregoing does not conflict with what I have been able to advance, namely, that in my opinion we are dealing with an Eocene fauna, for many of those shells collected to the south of the River Santa Cruz, and erroneously regarded as coming from the Patagonian Formation, have all been recognized as extinct species. This same horizon is

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respect to individuals they must have been more numerous than all the rodents of our pampa taken together. These animals have hitherto appeared to constitute an entirely extinct group without any direct affinities to any of the existing ones. Great, then, was my surprise when I received a letter from the distinguished zoologist of the British Museum, Mr. Oldfield Thomas, in which he informed me he had just received from Colombia (New Granada) an example of a still existing genus of the group of the Eocene Epanorthidæ of Patagonia, a genus which the gentleman in question will shortly describe. . . . Mr. J. B. Hatcher has lately informed me that the National Museum of Washington has just received an example of this same animal [= *Cœnolestes obscurus*, O. Thomas, Proc. Zool. Soc. 1895, p. 870, pl. L].

[1] F. Ameghino, "Enum. Synopt.," etc., 1894, p. 7.

[2] Mr. J. B. Hatcher, who collected all the Cretaceous mammals described by Marsh, recently examined in my house the remains of Plagiaulacoidea from Patagonia, and told me that in his opinion they exhibit the greatest resemblance to those of the Upper Cretaceous (Larami Formation) of the United States, described by Marsh.

shown well developed at Punta Arenas, covering in some parts the layers of lignite. The collection of fossil mollusca from this locality studied by Philippi, comes from this same horizon, with the single exception of *Ostrea Patagonica*, and all the species are considered by this distinguished malacologist to be extinct, and consequently as representing an Eocene fauna.

Now, it is also evident that that marine deposit (supra-Patagonian zone) and the Upper Santacruzian horizon form part of one and the same epoch, for in the lower portion of this terrestrial formation there are intercalated marine bands of the lower zone with *Ostrea Bourgeoisi* and other characteristic fossils of the same beds, resting upon deposits with remains of *Astrapotherium*, *Homalodontotherium*, *Proterotherium*, *Homunculus*, and all the other representatives of the marvellous mammal fauna of the Santa Cruz Formation.

We conclude from this, that the Santa Cruz Formation, and nearly the whole of the Patagonian Formation, represent in our country the complete series of the Eocene strata; while the lower and more ancient part of the Patagonian Formation, with the *Pyrotherium* beds which are found below it, corresponds with a portion of the Upper Cretaceous.

THE BOULDER FORMATION.

Above the earlier formations there come great sheets of basalt, and where this is wanting there is found the formation of Patagonian boulders, which, covering also the basalts, extend over the whole surface of Patagonia, both over the plateaux and over the slopes of the valleys; though the true boulder formation is that which covers the plateaux. The boulder deposits of the sides and the bottom of the valleys are the result of the falling down and transport at a comparatively modern period of the pebbles and boulders of the deposit which extends over the plateaux, and this is the only one with which I am concerned.

This deposit, perhaps the most gigantic boulder formation known on the surface of the earth, constitutes up till now a geological enigma. Of marine origin according to Darwin, who believed that nothing but the ocean could produce such a dispersion of boulders with the uniformity it presents, it has been regarded by almost all later authors as a product of the Glacial epoch. There is likewise difference of opinion as to the epoch to which it ought to be referred: Pampean according to some, it is of more recent date according to others, while there are not wanting those who believe that it immediately preceded the Pampean Formation.

In 1889,[1] relying on the data provided by C. Ameghino, which showed this formation to be in part derivative, with the materials appearing as if they had been rolled by water, and no trace of striæ or glacial polish or angular fragments which could have been transported by ice, I arrived at the conclusion that we were dealing with an accumulation produced by water without the intervention of glacial agencies. I recognized also that this accumulation might have been commenced at a most ancient period, since between the boulders and the Santa Cruz Formation there are no intercalated sedimentary deposits of any kind.

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[1] F. Ameghino, "Contrib. Conoc. Mamif. Fos. Repub. Argent.," p. 36.

The only difficulty which presented itself to me was, as to how the waters which descend from the Cordilleras to the Atlantic had been able to spread this boulder deposit in so uniform a manner, since the idea of marine action was excluded by the absence of marine remains in it. In any case, it will be a surprise to all, as it has been to me, to know that the Patagonian boulders are a marine formation, as Darwin originally said, but without any relation to glacial agencies and of a geological period much more remote than that to which all were more or less disposed to attribute it. On this subject Carlos Ameghino writes to me in a recent letter as follows:—

"Another of the facts also definitely ascertained on this journey, is the determination that the Tehuelche Formation, or that of the Patagonian boulders, is really a sediment of marine origin, as Darwin originally said, for now I have met with direct positive proofs such as the marine molluscs of that period are, with the only difference that, instead of being a formation of a comparatively recent period, as has hitherto been believed, it will have to be relegated to a much more remote period anterior to the Pampean Formation, because the species of *Ostrea* which it contains is of the same type and dimensions as the *Ostrea Bourgeoisi* of the Santa Cruz Formation. The reason why these deposits of fossil mollusca have hitherto escaped notice by all the explorers of Patagonia is, because they are completely isolated in the formation, and it is only in surveying an enormous superficial extent of the formation that there are chances of finding some of them by accident. These deposits occupy the summits of certain outliers of plateaux which have remained isolated and only rise a few metres above the general level of the surrounding plain, so that it appears as if at one time these fossils were distributed over all the remainder of the formation, but have only been preserved until to-day in these favoured spots and owing to causes which it has not hitherto been possible to explain to my satisfaction."

According to this, the boulders were deposited at the bottom of the sea, and over them there extended at other periods a vast formation of marine shells, of which there only remain diminished traces at certain definite spots. There was, then, after the epoch of the Santa Cruz Formation, a submergence of Patagonia, during which the sea penetrated as far as the foot of the Cordilleras; the definite emergence of those territories is posterior to the epoch of the boulder formation and of the banks of marine shells already mentioned superposed upon it. On the other hand, as the oysters of these banks are of large size and of a species similar to that characterizing the Santa Cruz Formation, there is every probability that the boulder formation is Miocene.

With this there certainly disappear the illusions of those who claim in some way to connect the boulder formation with a great

Glacial epoch; for although it is certain that there are yet some who believe not only in Miocene and Eocene, but also in Secondary Glacial periods, it is likewise certain that nobody pays attention to them.

THE TRANSVERSE VALLEYS OF PATAGONIA.

Having dispelled the ignorance as to the origin of the boulder formation, this leads us naturally to determine the age of the formation of the transverse valleys of Patagonia. It is evident that at the bottom of the ancient sea in which the boulders were deposited, these were scattered by the waters in a uniform manner over all the submerged territory. The same may be said of the sheets of basalt; those also must have extended in a comparatively uniform manner, without forming the steep cliffs which they exhibit to-day in the river valleys. Darwin, speaking of the scarps of the valley of the River Santa Cruz, said that the cliffs of basalt of the two opposite sides were recognizable immediately as at one time forming a continuous bed. The same may be said of the beds of boulders which in many parts form the opposite cliffs of the Patagonian valleys; those beds were continuous across the valleys, but there are now no traces of them.

It is evident that if the valleys had existed before the great marine submergence referred to, they would have been completely filled with marine deposits, which, even supposing they had been swept away afterwards by the waters, would always have left numerous traces buried in the innumerable angles of the slopes; but as such deposits do not exist, the inevitable conclusion is, that the formation of the great transverse valleys of Patagonia was brought about by great dislocations and gigantic faults at a comparatively recent geological period, posterior to the boulder formation and at the last emergence of the land.

THE PAMPEAN FORMATION.

As deduced from these data, the Pampean Formation must be of more recent date than the boulders of the Tehuelche Formation, and thus it is in fact, though in Patagonia it exhibits small development. We must, however, except the interior of the southern extremity, in the region of the River Gallegos, where the deposits of loess, superposed on the boulders, attain in some places a thickness of 15 to 20 metres. With respect to the whole, since no fossils have hitherto been found here, it cannot be affirmed categorically that these deposits correspond with the Pampean Formation of the province of Buenos Aires, and they may be of a much more recent period.

This doubt does not exist with respect to the isolated deposits met with from the River Coyle to the north, even at the bottom of the valleys as happens at the mouth of the Santa Cruz, or in depressions of the Tertiary formation of the coast like the deposit at San Julian which yielded to Darwin the first remains of *Macrauchenia*. Others occupy ancient bays of the ocean, and then we meet with bones of land-mammals mixed with marine shells; on his recent journey

Carlos Ameghino found several deposits of the latter nature in the gulf of San Jorge. All these isolated patches or deposits of the Pampean horizon contain remains of extinct mammals of the same genera and species as those of the Pampean Formation of the province of Buenos Aires, which proves that they are of the same period.

This similarity in the fauna of regions so far apart from south to north as the provinces of Buenos Aires and Santa Fé, and of southern Patagonia, demonstrates with the strongest proof that those are mistaken who invoke the intervention of glacial agencies to explain the accumulation of the pampean clay. It is Dr. Steinmann[1] who in a few words has most exaggerated the importance of the glacial phenomena in this part of America, since he regards as of glacial origin the deposits which are met with immediately below the Pampean Formation as far as and beyond the same horizon of Monte Hermoso. He does not state his reason for this, a circumstance which does not prevent many people from accepting his opinion because of the authority which the writer referred to enjoys in respect to geological questions. But in the present case he has not studied the question, for he is not only unacquainted with the deposits of Monte Hermoso, but even with the same Pampean Formation of the province of Buenos Aires; consequently, in judging this question without proper data he has fallen into a lamentable error.

In all my works I have repeated, even to weariness, that absolutely no trace of glacial marks is met with in the Pampean Formation—that neither the fauna nor the flora indicate during any part of it the existence of a climate colder than the present one. The six or seven distinct mammal faunas which succeed one another from the deposit of Monte Hermoso to the top of the Pampean Formation, all indicate without exception a climate warmer and more uniform than the present one. The remains of reptiles, the fresh-water mollusca, and the numerous plant-remains obtained from the Pampean Formation, lead to the same conclusion. It only remains to examine from this point of view the fauna of marine mollusca of the same period. With the object of supplying that deficiency I made an extensive collection of marine mollusca from the Pampean Formation and sent it to Dr. H. von Jhering, specialist on the subject, and this distinguished naturalist writes to me that almost all the species still live on the shores of the south of Brazil.[2] With this, the discussion on this point must remain closed, for I consider it an impossibility to discover positive facts in opposition to what we know up to now concerning the Pampean Formation and the characters of the faunas and floras of the same period.

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[1] G. Steinmann, "A Sketch of the Geology of South America": Amer. Nat. 1891, pp 855-60.

[2] H. von Jhering, "Conchas marinas da formaçao pampeana de La Plata": Revista do Museo Paulista, vol. i, 1895, pp. 223-31. This collection consists of nineteen species, all still existing on the Argentine coast except three, viz., *Purpura hæmastoma*, *Littorina flava*, and *Nassa polygona*: the first does not survive to the south of the Rio Grande del Sud, and the two last live in Santa Catalina, San Pablo, and more to the north. This indicates that the oceanic waters of that period had here a somewhat higher temperature than at present, which is in complete contradiction to the supposed glacial origin which some would attribute to the Pampean Formation.

I can summarize everything relating to this question in this form:—Absolutely no trace of glacial action is met with either in the Pampean Formation or in the immediately pre-Pampean deposits; and no plant-species, no mammal, nor any species of mollusc, whether marine, terrestrial, or fresh-water, indicating a climate colder than that of the present day, is known from the base of the Monte Hermoso horizon to the most modern of the Pampean deposits.

Traces of ice-action in the form of ancient moraines, striated and polished rocks, erratic blocks, etc., are confined to the modern formations, post-Pampean, and always in the neighbourhood of the mountains, proving a greater development of the snow-regions owing to local physico-geographical causes of a very recent geological date.

III.—OBSERVATIONS ON SEÑOR AMEGHINO'S "NOTES ON THE GEOLOGY AND PALÆONTOLOGY OF ARGENTINA."

By ARTHUR SMITH WOODWARD, F.L.S., F.G.S.;
Of the British Museum (Natural History).

THE general conclusions of the brothers Ameghino in reference to the geology of Patagonia, as detailed in the foregoing valuable synopsis of results, may be still more briefly stated in the following manner:—

(1) The oldest sedimentary rocks in which fossils have been found are red sandstones, containing mineralized wood, Dinosaurian bones, and other smaller reptilian remains. "*Upper Cretaceous.*"

(2) The terrestrial or fresh-water *Pyrotherium* Beds succeed these and may be partly intercalated with them. They contain a singular mammalian fauna, notably primitive Ungulata. "*Upper Cretaceous.*"

(3) For some distance from the present coast, but not far in the interior, the *Pyrotherium* Beds are covered by the marine Patagonian formation. "*Upper Cretaceous and Eocene.*"

(4) The Santa Cruz Formation, marine at the base but terrestrial and fresh-water above (major portion), rests on the Patagonian Formation near the coast, on the older rocks in the interior, and contains a large mammalian fauna. "*Eocene.*"

(5) Next are local sheets of basalt, and a great "Boulder Formation" proved to be of marine origin by the occurrence of shells. "*Miocene.*"

(6) Uppermost lies the Pampean Formation, chiefly of marine origin, with six or seven successive mammalian faunas.

For the substantiation of these results we must still await the publication of the sections and the detailed field observations of Señor Carlos Ameghino, which are already promised. Assuming, however, that the stratigraphical succession here tabulated is correct, the problem of the geological age of the various strata still admits of discussion. It is well known that most authors disagree with Dr. Florentino Ameghino in assigning the two early mammalian faunas he distinguishes to so remote an antiquity as that which he claims for them. It is clear that, judged by the standards of the northern hemisphere, the stage of evolution of these Patagonian faunas is much higher than any termed Eocene either in Europe or North America. I should therefore like to add a few new observations bearing upon the subject, which I was able to make during a visit to Argentina last autumn. Thanks to the kindness of the brothers Ameghino, I had the privilege of examining their unique collection; and Señor Florentino Ameghino gave to me (for the British Museum) the few fish-remains he possessed from the formations described. Dr. Moreno and Dr. Santiago Roth permitted me to study the collections in the Museum of La Plata, and Dr. Carlos Berg will shortly transmit to London for determination the series of fish-remains from Chubut and Parana now in the National Museum at Buenos Aires. Complete descriptions will appear later, but it is now opportune to make some preliminary remarks.

Firstly, as to the red sandstones with Dinosaurian remains, it may be added that Dr. Santiago Roth has recently brought back from the Territory of Neuquen a fine collection of the small undescribed reptilia to which Señor Ameghino refers (p. 10). One of these is a typical and apparently fully-evolved snake, which I had not time to study in detail. The others are small Crocodilia, of which I have prepared a description now being printed for the "Anales del Museo de La Plata." These crocodiles are particularly interesting because they are typically Mesosuchian, with the characteristic palate and amphicœlous vertebral centra. They seem to be most closely related to the small Purbeckian *Theriosuchus* and its allies, differing, among other features, in their more highly specialized dentition. Nearly all of them may be comprised in a new genus, which I have named *Notosuchus*. The skull is short and broad, with a much abbreviated rostrum, and the outer bones are externally rugose. The supratemporal fossæ are of moderate size, longer than broad; the orbits are relatively very large, directed both superiorly and laterally, and with a very slender internal post-orbital bar; a small antorbital vacuity occurs between the lachrymal and maxillary bones; and the nasals reach the single large narial opening, which is directed forwards. The mandible is slender, biting within the upper jaw, and its articular end is not curved upwards; there is a large vacuity in the side of each ramus, and the splenials enter the short pointed symphysis. The teeth are few in number and laterally compressed, some also feebly serrated; the series of the upper jaw is much differentiated, comprising two or three small "incisors" and one very large "canine" in each pre-maxilla, and seven teeth of more uniform size in each maxilla; while the series in the lower jaw comprises ten teeth on each side, these gradually increasing in size backwards and without any "canine." The limbs are typically crocodilian in every respect, and the fore-limb is not much smaller than the hind-limb. No dermal armour has been discovered with any specimen. The typical species, *Notosuchus terrestris*, has a skull about 0·15 m. in length. A second, closely-related genus, *Cynodontosuchus*, also exhibits the highly specialized dentition, but has *large* canines in the lower jaw, crossing and working upon those of the upper jaw. The typical and only known species is *C. Rothi*, with a laterally compressed rostrum.

Hence, the new crocodilian fossils tend to increase rather than diminish previous estimates of the antiquity of the red sandstones of Neuquen.

As to the *Pyrotherium* Formation, it would be premature to discuss its wonderful mammalian fauna until the appearance of Señor Ameghino's memoir which he is now preparing. I would, however, urge that he should show quite clearly why *Pyrotherium* cannot be a close ally of the Australian *Diprotodon* and *Nototherium* when he describes the fine skeleton he now possesses. It certainly differs from the Proboscidea in some most fundamental characters.

The few fish-teeth believed to have been obtained from the *Pyrotherium* Formation are unfortunately all marked with a query (?), and were thus apparently not found in actual association with the mammalian remains. But it is interesting to notice that one Selachian tooth from Lake Argentina belongs to the genus *Synechodus*, hitherto found only in the Cretaceous of Europe and New Zealand; while a number of teeth of Lamnidæ from the same locality cannot be distinguished from the common *Lamna appendiculata* of the English Chalk, and others seem to agree equally well with *Odontaspis* (? *Scapanorhynchus*) *subulata*. It may also be added that two teeth found with these are of the form commonly named "*Saurocephalus*," and seem to be identical with those of the Cretaceous ganoid fish, *Protosphyræna*. The remains of fishes met with in certain deposits in regions where *Pyrotherium* occurs, are thus of a decidedly Cretaceous aspect.

The Patagonian Formation is obviously the means for solving the age of the Santa Cruz Beds, for it seems to intrude into the midst of their lower portion. Señor Ameghino, on the authority of the conchologists, assigns to it a great age, believing it to be Upper Cretaceous and Eocene; and in discussing the Miocene or almost Pliocene aspect of the Cetacea of this horizon, he argues that they must have originated in the region of Patagonia and migrated to the northern hemisphere at a later date. This may be so, but we can now add that the few Selachian teeth from the same deposit are also of a decidedly Pliocene or Miocene character. *Carcharodon megalodon*, or teeth extremely similar to those thus named, occur in the Patagonian Formation of Chubut; so also do large teeth of *Oxyrhina*, identical with those of the European Miocene and Pliocene *Oxyrhina hastalis*—much larger than any hitherto found in a Cretaceous or Eocene deposit. If their evidence be of any value, therefore, we must argue that not merely the Cetacea but also the fish-fauna of the Miocene of the northern hemisphere originated at an earlier date in the southern hemisphere. But in the present state of our geological knowledge it is still necessary to use the chronological terms in question in a homotaxial sense, without reference to any theories of migration or contemporaneity. The relative age of the mammaliferous Tertiary strata in the two hemispheres thus remains still *too* uncertain to base upon them any of the wide generalizations which have already been attempted. The palæontologists of Argentina must be content for many years more to supplement the pioneer labours of Owen, Burmeister, and others, by the plodding detailed study of the unique osteological collections at their disposal; and none but those who have seen the material can appreciate thoroughly the overwhelming nature of this task.

IV.—ON THE EFFECT OF THE GREAT JAPANESE EARTHQUAKE OF 1891 ON THE SEISMIC ACTIVITY OF THE ADJOINING DISTRICTS.

By CHARLES DAVISON, Sc.D., F.G.S.;
King Edward's High School, Birmingham.

THE problem I have tried to solve in this paper is, whether the Mino-Owari, or great Japanese, earthquake of 1891 had any effect on the seismic activity of the surrounding regions. The effect we might anticipate would be either an increase or decrease in the frequency of shocks in those regions soon after the occurrence of the principal earthquake—a decrease if the stress were thereby diminished over the whole district, an increase if the stress were relieved in the central area and partially transferred to those adjoining it.

But, if such an increase, for example, were shown to take place, it would not necessarily be a direct consequence of the great earthquake. Both the central and the adjacent shocks, it is possible, might result from a general increase of stress over a wide extent of country, and the augmented frequency of the latter could not with justice be regarded as an undoubted effect of the former, for they might both be effects of the same cause. But, that the connection in the present case is one of real dependence, is very probable for the following reasons:—(1) An increase of stress cannot determine the occurrence of an earthquake, unless it be sufficient to overcome the resistance to displacement. Now, it is unlikely that the *gradual* increase of stress should be so nearly proportioned everywhere to the prevailing conditions of resistance as to give rise to a marked and practically simultaneous change in seismic activity over a large area; whereas the *paroxysmal* occurrence of a strong earthquake might alter the surrounding conditions with comparative rapidity, and so induce a state of seismic excitement in the neighbourhood. (2) The remarkable fault-scarp of the Mino-Owari earthquake was at least forty, and possibly seventy, miles in length; the vertical displacement reached 18 or 20 feet, and the horizontal displacement as much as 5 or 6 feet. A more serious change was "the permanent compression of ground, plots which were 48 feet in length now measuring only 30 feet in length. It appears as if the whole Neo Valley had become narrower."[1] It is clear that crustal distortions of this kind and magnitude could not be effected without a very considerable change of stress in all the surrounding country.

My object now is to ascertain how far this change of stress manifested itself by more frequent shocks, and for this purpose

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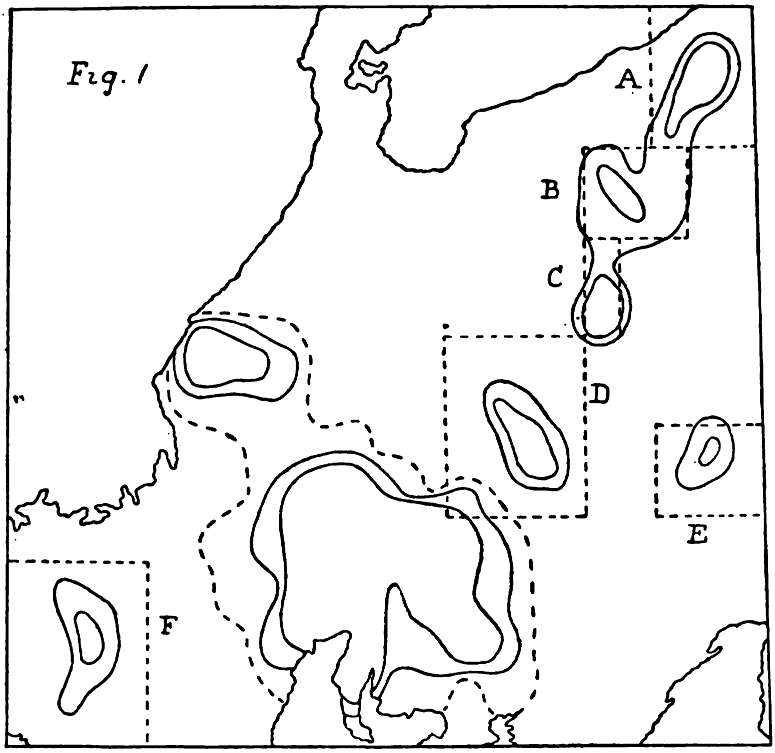
[1] Prof. J. Milne, Brit. Assoc. Rep. 1892, p. 117.

I have made use of Professor Milne's great catalogues of Japanese earthquakes during the eight years 1885–92.[1]

In the first[2] of the accompanying maps, the district in which the Mino-Owari earthquake and its after-shocks originated, is enclosed between the undulating dotted lines. The neighbouring regions whose seismic activity is to be investigated, are bounded by straight dotted lines, and denoted by the letters A, B, C, D, E, F. The curves represent the distribution of epicentres within and near these areas. In constructing these curves, the map is divided into rectangles whose sides are respectively one-sixth of a degree of latitude and longitude in length, so that sixteen of these rectangles adjoin the north-south side of the map, and twenty-one adjoin the east-west side, the whole map containing, therefore, 336 rectangles. The number of epicentres lying within each rectangle during the eight years mentioned being counted, curves are drawn through the centres of the rectangles in which five and ten epicentres respectively are found; or, when the numbers are not exactly five or ten, through points which divide the lines joining the centres of adjacent rectangles in



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[1] Seismol. Journ. of Japan, vol. iv, 1895.

[2] This map is bounded by the parallels 34° 40′ and 37° 20′ of north latitude, and the meridians 1° 0′ and 4° 30′ west of Tokio.

the proper proportion. The outer curve in each region corresponds to five epicentres in a rectangle, and the inner to ten epicentres.

In the central area of Mino and Owari, it will be noticed that the curve of ten epicentres is forked to the south. The great fault-scarp probably begins within the isolated curves in the north part of the area, and follows the east branch of the fork; but there can be little doubt that a second fault traverses the branch proceeding towards the south, though no corresponding scarp was observed upon the surface. The curves in the regions marked D and F seem to point to the existence of a pair of transverse faults, one on each side of the Mino-Owari fault-system, and roughly parallel to it. The earthquakes in the region A are probably connected with a strike-fault, and those in the region B with another transverse fault. The curves marked C and E are too small to offer any reliable guide as to the origin of the earthquakes within them.

In the following table are given the numbers of epicentres which lie within each of these regions, for every year from 1885 preceding the date of the great earthquake (October 28, 1891), and for every month following it until the end of 1892.[1]

	A	B	C	D	E	F
1885	3	2	...	5	7	8
1886	31	18	...	3	4	5
1887	7	4	...	2	1	1
1888	11	4	1	10·5	2·5	4
1889	5	1·5	2·5	1·5	2·5	1
1890	5	2	1	3·5	1·5	1
January 1—October 27, 1891 ...	4	4	1	4	...	0·5
November, 1891...	...	1	3	7	...	8·5
December ,, ...	...	2	1	1·5	...	9
January, 1892	2	1	19	7	...	7
February ,, ...	1	2	...	1	1	3
March ,, ...	...	1	0·5	5	...	1
April ,, ...	...	...	...	2	...	...
May ,, ...	...	...	...	...	...	...
June ,, ...	...	1	...	...	...	1
July ,, ...	...	...	...	...	...	...
August ,, ...	...	...	...	1	...	1
September ,, ...	...	1	8	2	...	1
October ,, ...	...	2	...	4	4	...
November ,, ...	...	1	...	...	...	2
December ,, ...	...	1	...	...	...	3
Number of shocks before the Mino-Owari earthquake ..	66	35·5	5·5	29·5	18·5	20·5
Number of shocks after the Mino-Owari earthquake ...	3	13	31·5	30·5	5	36·5
Ratio of average annual number of shocks after, to the average annual number before, the Mino-Owari earthquake ...	0·3	2·1	33·5	6·1	1·6	10·4

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[1] Occasionally an epicentre is defined in Professor Milne's catalogues as lying between two consecutive rectangles. In these cases I have counted half with each, and this accounts for the occurrence *of fractional figures* in the table.

The last line of the table shows that in every region but o (namely A) the frequency of shocks after the Mino-Owari eart quake is greater than it was before. In two other regions, B and the shocks during the succeeding fourteen months were relativel twice and one and a half times as numerous as during the precedin

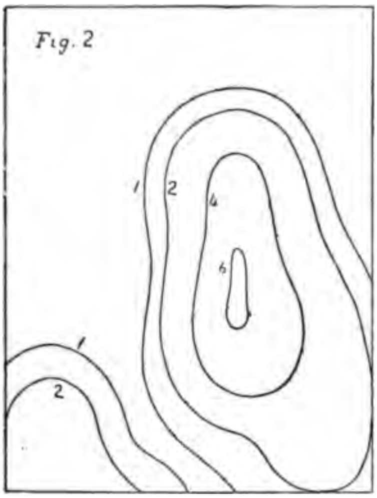
Fig. 2

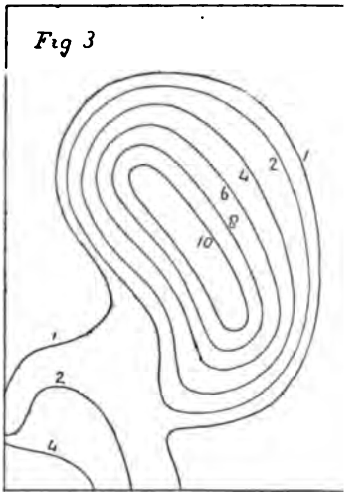
Fig 3

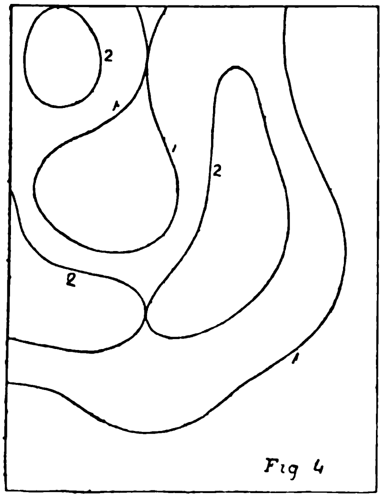

Fig 4

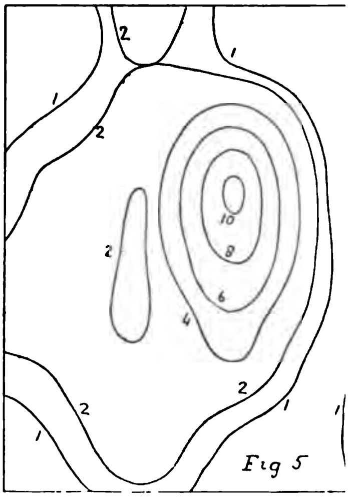

Fig 5

seven years; but the change is perhaps too slight to have muc significance. It is greatest of all in the region C, but this is chiefl due to the large numbers of shocks which occurred during t months of January and September, 1892; and it is uncertain ho far these were connected with the Mino-Owari earthquake.

It is in the regions D and F, those nearest the central area, that the change of frequency is most marked; and, as it takes place during the month following the great earthquake, it is difficult to resist the impression that the relation between them is one of effect and cause. The frequency curves for these two districts are shown in greater detail in Figs. 2–5. They correspond to 1, 2, 4, 6, 8, and 10 epicentres per rectangle. Figs. 2 and 3 refer to the region D, and illustrate the distribution of epicentres during the epochs preceding and following the principal earthquake, namely, from January 1, 1885, to October 27, 1891, and from November 1, 1891, to December 31, 1892. Figs. 4 and 5 relate to the region F for the same two epochs. The apparently aimless character of the curves during the earlier epoch in the region F, and their more definite form during the later in both regions, seem to me to point to the advent of new conditions governed by a simple law; and, in my opinion, there can be little doubt that the change was determined by the great earthquake of 1891.

V.—The "Great Submergence" Again: Clava.

By Dugald Bell, F.G.S.

A FEW years ago, in one of three or four papers treating of the "high-level shelly clays" of Scotland, I referred at some length to the interesting section at Clava, near Inverness, first described by Mr. Jas. Fraser, C.E., and inquired—Is it part of an old sea-shore or bottom, laid down by the sea where we now find it, and therefore proving a submergence of at least 500 feet?[1]

I submitted a number of facts and considerations which, I thought, tended to show that this instance at Clava cannot be received as a satisfactory proof of submergence.

Since that time, the Report of the Committee of the British Association on the deposit has been published. It disclosed a difference of opinion on this point among the members, the majority holding that the deposit is really *in situ*, and indicates a submergence of over 500 feet; while a minority thought the shelly clay may have been transported by land-ice, as in other well-known instances, and that this supposition was attended by fewer difficulties than the theory of a "great submergence."

The subject has again been brought up by Mr. John Smith, who visited the section once while the Committee's investigations were in progress. That single visit has been prolific in results. It enabled Mr. Smith offhand, without waiting for the Report, to instruct the public regarding the deposit; and it enables him now to pronounce, with all confidence, as to which section of the Committee is in the right.[2] As we have no pretension to be so swift and sure in our methods of working, we ask leave, in our old-fashioned way, to go over the ground again, and to restate, as concisely as we can, the reasons which appear to us to have weight against the "great submergence" on the one hand, and in favour of the "ice-transport theory" on the other. This is all the more necessary, as, although these reasons have been before Mr. Smith for a considerable time, and were repeated when he read his paper to the Glasgow Society in February last, he wholly ignores them, and publishes his paper now as if it had been received by the members without any words of objection, or any worth noticing.

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[1] Trans. Geol. Soc. Glasgow, vols. ix, x.

[2] Geol. Mag. for November, 1896.

Mr. Smith's "interpretation" of the section is simply the "old familiar" one of submergence, with some accommodating "currents" of his own, to which we shall afterwards refer. He evidently does not "stickle" at the *degree* of submergence, for he requires, at one stage at least, "*deep water without currents*" at Clava, which we take to imply not only a submergence of fully 500 feet to that point, but not less than 500 or 600 feet more, or, say, over 1000 feet in all. This is a pretty "large order" in the way of a submergence; but Mr. Smith seems to think nothing of it, and hints that he has still larger "orders" on hand for several places in Ayrshire!

(1) Now, the first and most obvious remark about such a submergence (or even one of 500 feet) is, that *if* the sea had reached the level supposed, or anything approaching to it, so recently as in Glacial times, it should have left traces of itself in innumerable localities all over the country. The sea leaves marks of various kinds—wave-worn cliffs, well-marked beaches, beds of shingle, sandbanks, clay-beds, besides organisms of many species, the relics of which are capable of being preserved, more or less perfectly, for very lengthened periods. When some of these evidences are wanting, others are sure to be found, if the sea has really been there.

This is true, not only of the *maximum* elevation, but also of every *intermediate* elevation down to the present sea-level. Both during the progress of the depression, and again during the progress of the re-elevation, such marks and traces of the sea as we have spoken of would be left, and would have a chance—a double chance, so to speak—of being preserved. They should, therefore, be common on our hills and among our glens, in all parts of the country, at the present day.

But, strange to say, whenever we go much above the present sea-level, such marks of the sea and such traces of undoubted marine deposits *in situ*, are everywhere "conspicuous by their absence." This is a great difficulty, even for a moderate submergence; but it seems insuperable in regard to a "great submergence." The greater the submergence, the wider the area, of course, on which the marks of the sea would be left. It becomes impossible, then, to explain the absence of all such traces, not only at the high level it is supposed to have reached, but at all lower levels at which, in its gradual progress and retreat, the sea must have remained for some time—probably at some of them for a long time—down to the latest well-marked beach above the present shoreline.

(2) This difficulty, while of weight in regard to the country generally, applies with peculiar force to the district around Clava—to the Great Glen in its immediate neighbourhood, and to the numerous side glens and valleys where, as the advocates of submergence themselves admit, traces of the sea, if it had been there, would have had the greatest likelihood of being preserved.

During such a submergence the Great Glen (or Caledonian Canal) and its chain of lakes would form a long, deep, intersecting arm of the sea, stretching from side to side of the country. The highest part of the Canal at Loch Oich is not more than 105 feet above the sea, so that, when the submergence was about 600 feet, the sea must have risen 500 feet along the hills on either side of the summit-level of the Great Glen. At 1000 feet all the hills of moderate elevation would be well-nigh half-submerged; and at the same time, it must have extended far up into every side glen, of which there are many, receiving and spreading out deposits there in every bay and inlet and sheltered recess of the land. And it must have done so for a long time, as those who require a submergence to account for thick deposits of fine clay must admit. How is it, then, that no traces of the sea have been discovered on either side of the Great Glen, at any one of the many elevations which the sea, by hypothesis, reached up to 600, up to 1000 feet? Neither in the main glen, nor in any of the side glens, has a single marine shell-bed, or bed of marine sand and gravel, or slope of wave-worn, cave-hollowed, or perforated rock been detected. The beaches of the old glacier-lakes in Lochaber are still clear as daylight, while the great ocean, sweeping to and fro across the country, and going into every nook and crevice of it, and full of life, has in all these places left "not a wrack behind"!

(3) The supposition that the traces of the sea were removed by a subsequent glaciation was examined on a former occasion, and found to be untenable.[1] Besides, if a subsequent glaciation ploughed out and removed all the marine beds deposited during the submergence (which seems impossible), then the Boulder-clay, the product of that glaciation, should undoubtedly be full of more or less broken and abraded marine organisms, instead of being, as a rule, entirely destitute of them. This has been admitted to be a difficulty which cannot well be got over.[2]

(4) A submergence of 1000 feet, or even much less, must in all probability have extended over a wide area. How far did the supposed submergence at Clava extend? In Caithness there is no evidence of any such submergence. In the southern part of the country the ice has come from the interior *seaward*, and the Boulder-clay there contains *no* shells. In the northern part, owing to the blocked condition of the North Sea, the ice has curved round and been pressed *on* to the land again, and there the Boulder-clay is full of shells and shelly fragments. Similarly, in Aberdeen the

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[1] Trans. Geol. Soc. Glasgow, vol. ix, p. 109.

[2] Geol. Mag., August, 1895.

grey till formed from the native rocks contains no marine organisms, which are restricted to sands and clays containing (like the Caithness shelly Boulder-clay) fragments of rocks foreign to the district, and which seem to have been borne inland along with the shells, etc., from the sea. (See Peach and Horne on the Glaciation of Caithness; Jamieson on the Shelly Clays and Gravels of Aberdeenshire.)

(5) Again, supposing such a depression and collapse of the earth's crust, say over the area of the British Isles, or a great part of it, where is the probability that the sunken part, after some tens of thousands of years (in all likelihood), should re-emerge, presenting much the same aspect as before, the same general arrangement of hills and valleys, the same climatic conditions over again, with very little to show for the prolonged submergence, except a few stray patches here and there of shelly clay, the very paucity and the distribution of which suggest that their present position is due to another cause?

The difficulty is not the submergence alone (though that is sufficient, without the very clearest proof, when one of such magnitude is concerned), but the submergence *plus* the re-emergence that followed.

(6) Another consideration, which has been alluded to more than once of late years, is that such a submergence would in all probability be accompanied by much milder climatic conditions, of which marine organisms found at high levels, if in place, would furnish clear indications. (See Lord Kelvin "On Geological Climate," Trans. Geol. Soc. Glasgow, vol. v.)

We submit that these objections, and others that might be stated, ought to be considered and answered in some degree before we are asked still to accept the old, crude, "rough and ready" theory of a "great submergence." It is worthy of note, ere leaving this part of the subject, that the objections which have been urged, of late years especially, to such a submergence in this country are precisely similar to those which the American geologists have urged with unanswerable force in regard to certain high-level terraces that were formerly supposed to be sea-beaches, but are now clearly made out to be old lake-margins. A general subsidence of the country was the theory formerly adopted. But as Professor G. F. Wright states the case—"There is no such amount of collateral evidence to support the theory of general subsidence as there should be if it had really occurred. The subsidence of the lake region to such an extent would have left countless other marks over a wide extent of country, but such marks are not to be found. Especially is there an absence of evidences of marine life. The cause was evidently more local than that of a general subsidence." ("Ice Age in North America," p. 353.)

In our next we shall consider the *pros* and *cons*—especially some of the alleged *cons*—of the alternative, or ice-transport, theory.

VI.—British Geological Photographs.

By W. W. Watts, M.A., F.G.S.

A YEAR ago, by the decision of the Council of the British Association, there was sent to the Museum of Practical Geology a large collection of photographs mainly taken with a view of illustrating, in the most permanent and unbiassed way at present possible, the features and phenomena of geological interest in the United Kingdom. The project of forming such a collection originated with Mr. O. W. Jeffs in 1888, when he read a paper on the subject at the British Association at Bath, in which he pointed out the utility of such a collection and the necessity for forming it. When a committee was appointed in the following year he undertook the management of the work, and he has carried it on for seven years with indefatigable industry and scrupulous care, only relinquishing it when the size of the collection began to exceed the capabilities of private control, and when his own lack of leisure no longer permitted him to devote the requisite time and attention to its custody. Twelve hundred photographs had been acquired by 1895, and it was then thought advisable that the collection should be lodged in the Library of the Museum of Practical Geology, where it would be available for reference by all those who wished to make any real use of it.

The year that has just elapsed has been occupied in cataloguing and rearranging the collection so as to make it more easy of access and reference. This has been rendered possible by the adoption of self-binding mounts of standard size (15½ in. by 12 in.), which can be shifted into different portfolios as required. The work is now far advanced towards completion, but the necessary remounting of the earlier part of the collection is a matter of time and expense, so that it may not be quite finished even within the present year. Still, the most valuable part is that which is being dealt with first; and only those districts which are already well illustrated, and even in some cases over-illustrated, are being left until a later period.

It has been thought worth while at this stage to publish some account of the purposes of such a collection, to describe the character of what has been already brought together, and to indicate the directions of future development; for it must at once be stated that finality has been by no means reached yet, and there is a great deal of work which ought to be completed in the next few years before the whole country will be well illustrated, and before, so to speak, sufficient capital has been created to enable the collection to exist on its average income.

The objects of the collection can soon be stated. It is obvious, in the first place, that it is well to have geological phenomena of all sorts photographed: pictures so taken, under proper precautions, are entirely trustworthy; the personal element can hardly enter into them, and they as a rule present the bare facts denuded of the halo of interpretation. A paper by Mr. Cope Whitehouse on Fingal's

Cave presses home this truth, and makes a good deal of fun out of the old illustrations and drawings of this curious feature when compared with a photograph. The comparison is quite justifiable when and where photographic illustration is possible, and one would be only inclined to point out that, not a single photograph, but several, are usually required, so that the thing may be seen in the solid and not in one plane, and that drawings are, and always will be, the necessary adjunct to the photograph if we are to interpret as well as see. Very many phenomena readily submit to photographic treatment, and though the first qualifications of a geologist should be travel, and travel, and again travel, he cannot see everything, and even the most experienced traveller may be guided and helped by seeing photographs before he visits a place, and may correct his impressions by means of them when he comes back, or, if he himself does not need such an aid, they may at least be useful to him in convincing his friends who have not been so fortunate. How we should like to have, for instance, a photograph marked by Salter himself, to show exactly where he drew his line between the Caradoc and Llandovery rocks, or of some of the older type fossils which it is so hard to recognize in our museums.

It is still more important to preserve such photographs as have been used to produce process blocks for scientific purposes, or as a basis for the preparation of drawings; the committee has already begun this work, and proposes to continue it if the friendly aid of editors of geological publications can be secured. As an example of what can be done we may refer to the splendid series of photographs of the dry valleys about Clapham in Yorkshire taken by Mr. Bingley to illustrate Mr. Tate's paper in the Proceedings of the Yorkshire Geological and Polytechnic Society. This is but one of the more recent examples, but many others might be quoted. Microphotographs of organisms and rock sections, views of quarries, boulders, glaciated surfaces, pebbles, structures in aqueous, igneous, and foliated rocks, and a host of other things, frequently reproduced by process or drawings, ought to be represented in this collection by permanent prints from the original negatives.

Again, for educational purposes it would be a very good thing to replace many of the venerable drawings which have so long done duty in the textbooks for representations of unconformity, bedding, dykes, cleavage, joints, faults, contortions, and many other elementary phenomena, by reliable photographs representing the actual facts as the student will really see them. When the collection has further advanced it should be possible to make a very perfect selection from it to illustrate such points, but hitherto it has not been large enough for the purpose, nor has any publisher been found willing to undertake the risk of reproducing such a set of illustrations, although it has often been asked for by those engaged in teaching. It is true that it is not so difficult to obtain illustrative photographs as it once was, and there are some educational series issued by professional and skilful photographers in England, Scotland, and especially in Ireland, which provide a great deal that is required; it is not quite inconceivable that the influence of the collection has had something to do with bringing about this result. But much of the work of amateurs is not at present available for this purpose, although it is superior to all but the very best professional work in the facts it delineates, albeit usually inferior in technical execution. As the committee's work progresses it should be possible to indicate where pictures of the most typical examples of rock-structure, features of landscape, phenomena of denudation and deposit, glacial action, etc., are to be obtained, even if it should still not be possible to reproduce them by process in a collected form.

The element of time enters into the interest of this collection in at least two ways. Firstly, we may sometimes register the effects produced by geological causes during the lapse of years. The advance of the sea at Reculvers would impress us even more than it does in the two drawings copied in Lyell's "Principles," if he had been able to give two photographs taken from the same spot instead. In Britain we cannot register such physiographic changes as the destruction and rebuilding of volcanic cones, the uprise and downfall of the sea, the effects of great earthquakes, the advance and retreat of glaciers, and the like; but we have landslips, floods, the filling up of lakes and estuaries, the advance of sand-dunes, and erosion by streams, seas, waterfalls, and wind.

One of Miss Andrews' photographs shows an unexpected instance of this kind: a pump erected in 1824, to get the water out of a stone quarry near the coast in County Down, is now to be seen 50 feet out at sea; and one by another hand shows that the shaft at the back of an old cave by which smugglers used to pass their ill-gotten goods inland is now at the mouth of the cave, and all but cut away by the general wear and tear of the coast, while the cave itself has been worked back. Others show in minute detail the outline of the coast at Filey, Flamborough, Sunderland, etc., so that it will be possible to see the progress of future denudation by comparison with them.

On the other hand, the duration of exposures of geological features is often only temporary: railway cuttings become grassed over, quarries abandoned and closed, trenches and subterranean works filled up and built over, rock exposures soiled over and planted, or even submerged, boulders are broken up and disappear, sea cliffs are worn back or hidden by landslips. All these things might be preserved on paper, so that it is possible to check conclusions founded on them by reference to photographs even when they are no longer open to examination. The Cambridge Greensand is becoming an unseen stratum, the Crags are gradually disappearing, gravel beds and road-metal quarries are being worked away, stones formerly much worked are being abandoned; records in the form of photographs as well as descriptions ought to be kept. Sir H. T. Wood's photographs of the excavations in the Beer-stone, I believe, show features no longer to be seen; and the photographs of the stages of working of the great quarries at Bardon and Mount Sorrel preserved in the collection will be of interest to those who read the papers on Charnwood Forest, and even of greater interest to those in the future who shall find nothing but holes and talus heaps where the hills now stand.

Discussion at the Geological Society as to whether a bed dips this way or that, whether one rock is or is not intrusive into another, or on the nature of the junctions of strata, would occasionally have their acerbity softened by the exhibition of photographs which gave a true picture of the facts, while the record established by such photographs might serve as useful if, perhaps, at times inconvenient reminders.

The present collection contains many fine sets of views taken in series so as to illustrate particular points. Beginning with the north of England, the coast north and south of Tynemouth, for a considerable distance, has been photographed, including the Whin Sill and its contacts, the Carboniferous rocks, and the Magnesian Limestone, with its breccia-gashes and other beds of concretions about Marsden and Sunderland. Passing inland, we also owe to Mr. Garwood a very beautiful set of photographs illustrating with the greatest clearness the character and history of the Whin Sill and of the northern boulder-clays. In their own county Mr. Bingley and other members of the Yorkshire Naturalists' Union have given us a series, which it is to be hoped will eventually be completed, that serves as a picture survey of the coast, while inland we have the Clapham, Norber, Gordale, and other districts thoroughly represented.

Of the Eastern Counties we have very little, and that chiefly of Norfolk, but we have been promised a series, specially taken for our purpose, of the Crag district and parts of the eastern coast-line. Of the Home Counties, again, we have little; and of the characteristic scenery of the Weald there is not much to be obtained at present, in spite of the work of the East Kent Society, to which we owe most of what we have. Of Surrey we have little, of Sussex nothing, and of the Isle of Wight not nearly enough; but the Dorset coast and inland regions have been well treated by Mr. Cole, Mr. Bingley, Miss Andrews, and others. Parts of Devon and Cornwall have been dealt with in detail, but the prints have not yet been satisfactorily described and illustrated, partly, no doubt, on account of our limited knowledge of the minuter geology of these counties. Somerset has been treated by Professor Allen, Mr. Armstrong, and others, and its main features have been illustrated, but all that is necessary has not yet been done.

In the South Midland Counties, from Hertfordshire to Gloucestershire, but little has been collected, though Mr. Hopkinson has striven, by example and precept, to show what there is to do and how to do it. South and Central Wales, with the border counties of Hereford and Monmouth, are almost virgin fields. Of North Wales there are some capital photographs, including those of the Llanberis district, by Mr. J. J. Cole, but there is much still to be done in a country so rich in evidences of glaciation, with fine rock-structures, types of mountain form, and wealth of outcrop of rocks not so well seen elsewhere. The Ordovician ground of Shropshire has been illustrated, but much remains to be done in the Silurian and pre-Cambrian country, and amongst the newer rocks of the east and north; the same may be said of the counties of Stafford, Derby, and others of the North Midlands, except in Leicestershire, where, owing to the energy of the Leicester Philosophical Society and a few others, a great deal has been effected in some parts of the county, particularly in the classic ground of Charnwood Forest. Cheshire and Lancashire have been taken in hand by the Liverpool Geological Society, but much remains to be done in the large counties of Cumberland and Westmoreland, and especially in Lakeland. Something has been done in the Isle of Man, but the recent Survey work there requires photographic illustration.

Passing to Scotland, the more sensational regions of the lava plateaux have been illustated by numerous sets, but the ground of gneiss and schist in the North-West and of the Central Highlands requires much new work; the same might be said of the greater part of the Central Valley and the Southern Uplands. Mr. Kidston has done good work in Stirling, Mr. Coates in Perth, and Mr. Goodchild about Edinburgh, but not much other systematic work has been attempted. The names of Professor Heddle, Mr. Harvie Brown, Mr. Howie, and Messrs. Valentine, should be mentioned as having contributed to the Scottish part of the collection.

In Ireland, the Belfast Naturalists' Field Club was one of the first of the field clubs to undertake the definite collection of a set of photographs to illustrate their own district, and to contribute the proceeds to the central body; their able contributors, amongst whom it is a pleasure to name Mr. Welch, Miss Andrews, Mr. Gray, and Mr. Stelfox, have done much towards a photographic survey of their own county and those bordering it. Dr. Valentine Ball was instrumental in sending a set of prints illustrating the phenomena of the ancient rocks on Howth, near Dublin, while Dr. Tempest Anderson and Mr. Bingley have done much good work. The rest of the work may be safely left in the hands of those energetic field clubs which have begun so well, with the remark that such districts as the Wicklow Mountains, the beautiful tract of Limerick, the areas of ancient rocks in Galway and Mayo, and the Carboniferous and Old Red Sandstone rocks of Kerry, are all, literally, awaiting development.

In England and Wales we would call especial attention to the further photographing of the big boulders and ice-worn rocks which are rapidly disappearing, to the Malverns, the Cheltenham Oolites, and those of Dorset and Wiltshire with their Cretaceous rocks, the central Coalfields of England, the Lake Country and the Cheviots, the Dale district of Yorkshire, and the Southern and Central parts of Wales.

The future extension of the collection, like its past history, must depend very largely on the local societies and field clubs. These bodies are always asking what work they can do that will employ a good number of their members, and which, though not requiring too much technical knowledge, will really be a help in advancing natural knowledge. This is the very class of work required, and many of the societies have thrown themselves heart and soul into it. Many of them have already been mentioned in connection with the districts in which their work lies, but there are several others, such as the Chester Society of Natural Science, the Croydon Microscopical Society, the Dover Natural History Society, the Geological and Geographical Societies of Manchester, and the Geologists' Association, which have given ready help. Warwickshire has carried out a Photographic Survey of its dominions, including not only geological phenomena, but subjects of geographical, ethnographical, and archæological interest. It may not be yet possible to carry out such a comprehensive scheme as this in many cases, but it ought not to be difficult to get one or two enthusiastic photographers in each county to register at least the prominent and temporary features and phenomena of geological interest. Guidance and help, where it was needed, would be forthcoming from local geologists and the Survey, and it may be possible in the compass of a few years to have the whole of the United Kingdom fairly well represented, so that there would only remain the task, which will then have become an easy one, to photograph new sections as they are exposed, and new phenomena as they are recorded and understood. We should thus become possessed of a storehouse of fact to which the rising geologist can readily turn to see the state of knowledge at this particular date, to check the older work, and to measure the progress of physiographic change.

Our present experience with the collection shows that one of the great dangers which exists is the want of permanence of some of the prints. Kept away from the light as most of them are, it seems that the ordinary silver prints last fairly well when properly fixed and washed after toning; bromide prints, however, appear to last better, and, of course, platinotypes best of all. It is really worth while to sacrifice some of the depth and detail of shadow, at present an unavoidable defect of platinotype printing, in order to secure the greater permanence which these prints give. To those who take small prints it may also be said that enlargements are very satisfactory from the greater ease with which they can be studied; but it is advisable, by the use of a small stop or a very good lens, to get the negatives from which enlargements are to be prepared as sharp and clean as possible. Very good results are obtained by carbon enlargements, but the process is troublesome owing to the necessity for preparing an enlarged negative; still, such a negative is a valuable acquisition when once it has been made.

Every photographer knows the importance of illustrative drawings taken at the same time as the photograph, or, better still, with the photograph in hand when the section is revisited; such careful work as this adds immensely to the value of the photographs as a permanent record.

Some attempt has been made to make the photographs more accessible and useful by promoting exchange between contributors, and the Committee can always be utilized as a means of intercommunication; some photographers have been kind enough to place their negatives in the hands of professionals, from whom lantern slides and prints can be obtained on paying the expense of production. It would, however, be far too large a task for the Committee to undertake any further action in this matter or to assume the copyright of prints sent to them; this must remain in the hands of the original photographers, and arrangements must be made with them in each case.

In conclusion, I feel impelled to add a word about the regulations and forms issued by the Committee, which have been objected to in some quarters. In the first place no hard and fast rules are insisted on; only certain *hints* have been drawn up as they were suggested by the experience of the Committee, now somewhat considerable. Uniformity in size is unattainable, nor is it at all necessary with the present system of mounting, but the larger photographs are, up to whole plate size, the more easily they can be examined. Larger ones, up to 15 in. by 12 in., can be accommodated. For the reasons given before, permanent prints are obviously more likely to be useful to posterity than others. A scale of some sort, no matter what if its size is given, where necessary, in the explanatory form, is really required in order to impress the scale of the structure photographed; the human figure does very well—a hammer of stated size is convenient in smaller views if it is placed so that its entire length lies at right angles to a line joining the camera with the centre of the picture; an umbrella or walking-stick is quite satisfactory; or it suffices to indicate the length of some portion of the section, easily recognizable in the print, on the accompanying form. The use of the standard descriptive forms is very desirable; they are mounted with the photograph, and if the chief details are filled in they enhance its value enormously. It is very important that these forms should be sent, filled in, with the photographs to ensure absolute accuracy, and, although it is not necessary to attend to all the minute details for which space is provided, some of them, like the date (at least the year, and when possible the month) and the exact location, so that the place could be found again, should be carefully given. It has recently been my lot to fill in some hundreds of these forms for other people, and this has led me to appreciate the labour involved, but it has only convinced me more completely of the necessity for them, and that they should be filled up by those who know the locality and its geology well.

I am hoping to have a number of the older photographs looked over, as opportunity occurs, by those who are most familiar with the localities in question, so as to bring out to the fullest extent at present practicable the latent value and interest of the whole collection.

Note.—By the kindness of Mr. W. W. Watts we hope, next month, to be enabled to give one or two good illustrations in order to show the value of the work which is now being carried on by the British Geological Photographs Committee, initiated by Mr. O. W. Jeffs and carried on so successfully by him and by the Committee during the past nine years.—EDIT. GEOL. MAG.

REVIEWS.

I.—The Dinosaurs of North America. By Othniel Charles Marsh. (Extract from the Sixteenth Annual Report of the Survey, 1894–5. Part I: Director's Report and Papers of a theoretic nature. Department of the Interior, U. S. Geological Survey; Charles D. Walcott, Director.) Imperial 8vo, pp. 135–244, pls. ii–lxxxv. (Published at the Government Printing Office, Washington, 1896.)

THE name and researches of Professor O. C. Marsh are already familiar to the readers of the Geological Magazine, and his papers on the Dinosauria have been largely illustrated in its pages during the past fourteen years.[1] The publication, therefore, of the present Survey Memoir can hardly be expected to add much to the knowledge which we have already derived from the author's numerous and well-illustrated separate memoirs, which have from time to time been issued from Yale University, Newhaven, Connecticut. In the present volume we have brought together, into one focus, all the work Professor Marsh has done on the Dinosauria, but even now, many fine plates are held back for a further *edition de*

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[1] The following is a list of Professor Marsh's papers on Dinosaurs in this Magazine:—

(1) "Classification of the Dinosauria," O. C. Marsh: Geol. Mag. 1882, pp. 80–5.
(2) "American Jurassic Dinosaurs—Restoration of *Brontosaurus*," O. C. Marsh: op. cit., 1883, pp. 385–8, Pl. IX.
(3) "On the Diplodocidæ (Family Sauropoda)": op. cit., 1884, pp. 99–107, with Ten Woodcut Illustrations (four views of skull of *Diplodocus*, etc.).
(4) "The Principal Characters of American Jurassic Dinosaurs, of the order Theropoda": op. cit., 1884 (Eight Illustrations of *Ceratosaurus* and *Allosaurus*).
(5) "The Skull and Dermal Armour of *Stegosaurus*": op. cit., 1888, pp. 11–15, Pls. I, II, III, and Three Woodcuts.
(6) "Comparison of the Principal Forms of Dinosauria of Europe and America": op. cit., 1889, pp. 204–10.
(7) "The Skull of the Gigantic Ceratopsidæ": op. cit., 1890, pp. 1–5, Pl. I (*Triceratops flabellatus*, Marsh).
(8) "The Gigantic Ceratopsidæ or Horned Dinosaurs of North America": op. cit., 1891, pp. 193–9, Pls. IV and V, and Figs. 1–17, in text (*Triceratops prorsus*).
(9) "Restoration of *Triceratops prorsus*, Marsh": op. cit., 1891, pp. 248–50, Pl. VII (Restoration of the Skeleton of *Triceratops prorsus*, Marsh).
(10) "Restoration of *Stegosaurus ungulatus*, Marsh": op. cit., 1891, Pl. XI, pp. 385–7.
(11) "Restorations of *Anchisaurus*, *Ceratosaurus*, and *Claosaurus*, Marsh": op. cit., 1893, pp. 150–7. (Fig. 1, *Anchisaurus colurus*; Pl. VI, *Ceratosaurus nasicornis*; Pl. VII, *Claosaurus annectens*.)
(12) "Restoration of *Camptosaurus dispar*, Marsh": op. cit., 1894, pp. 193–5, Pl. VI.
(13) "Restorations of some European Dinosaurs, with Suggestions as to their place among the Reptilia," by O. C. Marsh: op. cit., 1896, pp. 1–9. Pl. I, *Compsognathus longipes*, Wagner; Pl. II, *Scelidosaurus Harrisoni*, Owen; Pl. III, *Hypsilophodon Foxii*; Pl. IV, *Iguanodon Bernissartensis*, Boulenger.
(14) "Classification of Dinosaurs": op. cit., 1896, pp. 388–400, with twelve restorations of dinosaurs, to scale, in the text, namely: 1, *Anchisaurus*; 2, *Compsognathus*; 3, *Ceratosaurus*; 4, *Brontosaurus*; 5, *Stegosaurus*; 6, *Scelidosaurus*; 7, *Triceratops*; 8, *Camptosaurus*; 9, *Laosaurus*; 10, *Hypsilophodon*; 11, *Iguanodon*; 12, *Claosaurus*.

luxe, which we hope the learned author will not long postpone to bring out.

In his brief Introduction, the author tells us that the true place of the Dinosauria in the animal kingdom has been a matter of much discussion amongst anatomists, but the best authorities now regard them as constituting a distinct subclass of the Reptilia. Some of the large, earlier forms are apparently related to the Crocodilia, while some of the later small specialized ones have various points of resemblance to birds. These diversified characters make it difficult to classify the dinosaurs among themselves, and have led some writers to assert that these reptiles do not form a natural group, but belong to divisions remotely connected, and not derived from a common ancestry.

Without discussing in detail the classification of this group, it may be stated in a few words that three great divisions of the Dinosauria are generally recognized, which may be properly regarded as distinct orders. For these groups the author has proposed the names THEROPODA for the one including the carnivorous forms, and SAUROPODA and PREDENTATA for the two herbivorous groups, the last order being made up of three separate suborders, namely, the Stegosauria, the Ceratopsia, and the typical Ornithopoda. The first of these suborders contains large dinosaurs, more or less protected by a dermal covering of bony plates; the second group includes the huge horned dinosaurs; and the third is made up of the forms that in shape and structure most nearly resemble birds.

Commencing with the Triassic deposits, we find that a dinosaur (*Clepsysaurus Pennsylvanicus*, Lea) was made known from a few bones, found in 1847, and described by Dr. Isaac Lea in 1851; and a jaw with teeth, named *Bathygnathus borealis* by Dr. Leidy, from Prince Edward Island, Canada, was described in 1854 (Journ. Acad. Nat. Sci. Philad. 1853 and 1854). A third, named *Megadactylus polyzelus*, was discovered by the veteran Professor E. Hitchcock in 1856, and described in 1865 by his son, E. Hitchcock, jun.

A nearly complete carnivorous dinosaur was discovered in 1884 in the same Connecticut River series of Triassic age, and named by Marsh *Anchisaurus colurus* (see plates ii, iii, iv, op. cit., and GEOL. MAG. 1893, Fig. 1, p. 150). The foot of another Triassic form (*Ammosaurus*) is also figured, and reference is made to dinosaurian Triassic footprints, the so-called "bird-tracks" of the Connecticut River series. The occurrence of *Thecodontosaurus* in the Trias of Bristol (England), and *Plateosaurus* (*Zanclodon*) in Germany, completes the European and American Triassic forms, but other remains have been found in India, in South Africa, and in Australia.

In the Jurassic strata of Colorado, Professor Marsh has discovered a small Theropodous dinosaur of carnivorous habits, about the size of a rabbit, in which the metatarsals of the hind-limbs are greatly elongated, suggesting the generic name of *Hallopus*, or leaping-foot, from its probable mode of progression. In another higher stratum of the Colorado series the genus *Cœlurus* is met with, of the same small type as *Hallopus*. Both these are probably near relatives of *Compsognathus*, from the Lithographic Stone of Solenhofen (plate lxxxii; and Geol. Mag. 1896, Pl. I, and p. 392, Fig. 2). These are among the smallest of the class.

One of the largest carnivorous forms was *Ceratosaurus* (*C. nasicornis*, Marsh), measuring some 18 ft. in length and standing nearly 15 ft. from the ground. It had a horn-core on the nasal bone; the bones of the pelvis are all co-ossified, as in existing birds; the metatarsal bones are also co-ossified, a feature characteristic of birds, but not known hitherto in any other dinosaur. The premaxillaries each contained three, and the maxillaries had each fifteen, large, powerful, and trenchant teeth, clearly indicating, as in our own Oolitic *Megalosaurus*, the ferocious character of the animal.

Of the other carnivorous dinosaurs of the American Jurassic, three genera, *Allosaurus*, *Creosaurus*, and *Labrosaurus*, are specially worthy of notice. All were represented by species of large size, the natural enemies of the gigantic herbivorous forms that were so abundant in the same period. All had powerful jaws, sharp, cutting teeth, and a flexible neck. The fore-limbs were quite small, and the feet (manus and pes) were armed with strong claws for seizing living prey. The hind-limbs were large and strong, and the animals used them alone in ordinary locomotion.

The herbivorous dinosaurs of the American Jurassic are of special interest, comprising in the Sauropoda the most primitive and gigantic forms, and also one of the most diminutive, *Pleurocœlus*. The Atlantosauridæ include the largest forms; the Diplodocidæ and Morosauridæ are both represented by gigantic species; whilst the small Pleurocœlidæ appear to be the last survivors of the order in North America.

Remains of the first three families are abundant in the *Atlantosaurus* beds of the West; and the locality near Lake Como, in Wyoming Territory, has now become one of the most famous in the entire Rocky Mountain region, having yielded to Professor Marsh remains of several hundred dinosaurs.

Atlantosaurus is only known from imperfect remains, but the pelvic bones and femur of *A. immanis* give an idea of its gigantic size. The femur is over 6 ft. in length, and this, with the other portions of the skeleton, indicates, says Marsh, an animal about 70 or 80 feet in length! *Apatosaurus* is a nearly allied genus. In *Brontosaurus*, the type-specimen being a nearly entire skeleton, we obtain by far the most complete and accurate knowledge of any of the Sauropoda yet discovered. In *Atlantosaurus* and *Apatosaurus* there are only three coalesced sacral vertebræ, in *Brontosaurus* there are five. Although about 60 ft. in length, its skeleton is distinguished by the peculiar lightness of its vertebral column, the cervical, dorsal, and sacral vertebræ all having very large cavities in their centra; the first three caudals, also, are lightened by excavations in their sides.

The head of *Brontosaurus* was remarkably small; the neck was long and flexible, and was the lightest portion of the vertebral column. The body was short, and the abdomen of moderate size. The legs and feet were massive, and the bones of the limbs all solid. The feet were plantigrade, and each footprint must have covered about a square yard! The tail was large, and nearly all the bones were solid. The very small head and brain and the slender neural cord, indicate a stupid, slow-moving reptile. The beast was wholly without offensive or defensive weapons or dermal armature. ***Barosaurus*** is an allied form. Of European forms ***Cetiosaurus longus***, from the Great Oolite, Oxford, ***Ornithopsis Hulkei***, from the Wealden of the Isle of Wight, have the skeleton constructed like ***Brontosaurus***, with the same large cavities in the centra of the vertebræ. The teeth named ***Hoplosaurus armatus***, Gervais, from the Wealden, Isle of Wight, are also identical in form with those attributed to ***Brontosaurus excelsus***, Marsh.[1]

One of the most remarkable heads of any of this curious group is that of ***Diplodocus***, which, when seen in profile, forcibly recalls the expression of the "Mock-turtle" by J. Tenniel, in "Alice in Wonderland." The orbits are large and placed far back in the cranium; the facial portion is elongated and broadened in front; the nasal opening is very large and placed near the apex of the skull. The teeth, which are very weak, slender and cylindrical in shape, resemble a row of bluntly-rounded pins; they are all crowded to the front of the jaws, 4 in each premaxillary and 9 in each maxillary = 26 above, and 10 in each dentary of the lower jaws = 46 in all. A section of the maxillary bone shows provision for an abundant succession of new teeth when required, and from their shallow insertion they would probably have been readily detached. No restoration is given of *Diplodocus* save of the skull; but the beast was probably intermediate between *Atlantosaurus* and *Morosaurus* in size, and from 40 to 50 feet in length. The teeth indicate an herbivorous diet, the animal feeding largely upon succulent vegetation, and the position of the nares seems to indicate an aquatic mode of life. *Morosaurus* is placed near to *Diplodocus*. The limbs suggest a plantigrade progression, as in *Brontosaurus*. There does not appear to be any representative of *Diplodocus* out of North America.

In the division named by Marsh the PREDENTATA, all the members have a predentary bone (called by Hulke the presymphysial bone), which is absent in all other dinosaurs, but is present in fishes of the genera *Aspidorhynchus* and *Belonostomus*. This order includes the Stegosauria (or plated lizards), the Ceratopsia (or horned lizards), and the Ornithopoda (or bird-footed dinosaurs). All these are herbivorous forms.

Stegosaurus probably rivalled *Brontosaurus* and the other non-plated dinosaurs in size: all its bones, however, were solid; the vertebræ were biconcave; its body was defended by strong compressed dorsal bony spines and plates, which in life were encased in horny sheaths; its head was very small in proportion to the size of the entire animal, whilst its brain was only $\frac{1}{100}$ that of an alligator, if the weight of the entire animal be brought into comparison; indeed, it may be said to have had one of the smallest brains of any known land vertebrate. The teeth are small. with compressed, fluted crowns, separated from the roots by a more or less distinct neck. Owen's genus *Omosaurus*, from the Kimmeridge Clay of England, cannot be separated generically from *Stegosaurus*. *Scelidosaurus*, from the Lias of Charmouth, also agrees with it in the structure of its teeth and in the possession of dermal armour.

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[1] Similar remains have been met with in Madagascar and in Patagonia.

In *Camptosaurus* we have a form of dinosaur which in general appearance resembles the *Iguanodon* from Bernissart. The sternum in *Camptosaurus*, however, is entirely unossified, and no trace of clavicles has been found. In the manus of *Camptosaurus* there are five functional digits, the first being flexible and parallel to the second, not stiff and divergent like the thumb of *Iguanodon*. The pes (hind-foot) has three functional digits only, the first being rudimentary and the fifth entirely wanting (as shown on plate lvi). It is a more slender form than *Iguanodon*. *Dryosaurus* is a genus allied to *Camptosaurus*, also from the *Atlantosaurus* beds of Colorado and Wyoming.

Laosaurus is a diminutive dinosaur possessing many avian features, now only seen in existing, and more especially in struthious, birds. The European representative of *Laosaurus* is the *Hypsilophodon Foxii* of the Wealden of the Isle of Wight. *Nanosaurus agilis* is the name given to another, quite small dinosaur, allied to the foregoing, having strong bird-like characters in its anatomy.

The Ceratopsidæ, or huge horned dinosaurs from the Cretaceous rocks, are an outcome of Converse County, Wyoming, where, in a limited area near the Cheyenne River, Mr. J. B. Hatcher found more than thirty specimens. In the largest individuals the skull (in *Triceratops*) exceeds that of any *land* animal hitherto discovered, living or extinct, and is only surpassed by some of the marine Cetacea. One head, when complete, must have been 7 or 8 feet long. Two others, nearly perfect, from the same horizon, have equal or still greater dimensions. Another striking feature is its armature. This consisted of a sharp cutting beak in front, a strong horn on the nose, a pair of very large pointed horns on the top of the head, and a row of sharp projections around the margin of the posterior crest. All these had a horny covering of great strength and power. For offence and defence they formed an armour for the head as complete as any known. In some forms the armature extended over portions of the body. The skull is wedge-shaped in form, the facial portion being very narrow in front, and prolonged; the frontal region is massive and greatly strengthened to support the large and lofty horn-cores which formed the central features of the armature. The huge, expanded, posterior crest, which covered the back of the skull and overshadowed the neck, afforded attachment to the powerful ligaments and muscles that supported the head. Several other genera, as *Torosaurus*, *Ceratops*, *Sterrholophus*, *Agathaumas*, *Polyonax*, and *Monoclonius*, are referred to, and the first two are figured. One feature of interest must not be omitted; it is that the teeth have *two distinct roots*: this is true both of the upper and lower series. The roots are placed transversely in the jaw, and there is a separate cavity, more or less distinct, for each of them. No fewer than ten vertebræ are co-ossified in the sacrum of *Triceratops*; whilst the middle, or true sacral vertebræ, have double transverse processes to support the ilium—a character hitherto only seen in *Ceratosaurus* and other Theropoda.

Another American type of dinosaur is represented by the genus *Claosaurus*, from the Cretaceous of Kansas.

The skull is long and narrow, with the facial portion especially produced, and slightly expanded in front, very like the head of an anserine bird when seen from above. The extremities of the premaxillaries are beak-like, and the predentary bone is robust and fitted to meet the strong beak above. The teeth in *Claosaurus* are confined entirely to the maxillary and dentary bones. They are very numerous, and are arranged in vertical series, so that they succeed each other as the functional teeth are worn away. The number of teeth, as shown in the drawing, may be as many as 38 to 40, above and below, on each side, if they are correctly shown on pl. lxxii, fig. 1; but "*six* or more" is the number mentioned in the text on p. 221 (this should probably be 66).

The whole vertebral column was found *in position*, except the terminal caudals, which are represented in outline. The first and second caudals have no chevrons. Behind these the chevron-bones are very long, indicating a powerful, compressed tail, well adapted for swimming.

Between the ribs and the neural spines, in the median dorsal region, are very numerous rod-like ossified tendons, which increase in number in the sacral region and along the base of the tail, and then gradually diminish in number and size, ending at about the 35th caudal. These tendons resemble those in the Bernissart *Iguanodon* described by Dollo, and must have added greatly to the strength of the dorsal region in these old vegetable-feeding dinosaurs, whether in raising themselves into an erect position, or to assist them in the act of running, or swimming, to escape from their carnivorous enemies.

The fore-limbs of *Claosaurus* are unusually small in comparison with the posterior. The manus was very long, and had three functional digits: two (2nd and 3rd) were of equal length, but the 1st was rudimentary, the 4th was shorter and less developed, and the 5th was entirely wanting. The ends of these phalanges were blunt, and were probably covered with hoofs and not with claws. The hind-foot, or pes, had but three digits (as in *Iguanodon*), and the terminal phalanges were covered with broad hoofs.

In the conclusion comparisons are made, by means of a series of figures, of the various parts of dinosaurs. Skulls are depicted of typical genera of such herbivorous forms as *Triceratops*, *Claosaurus*, *Camptosaurus*, and *Diplodocus*, giving the brain-cavity in position, to illustrate the diminutive size of the brain in each in proportion to the skull; the form of the brain-cavity seen from above is given, also casts of the brain seen from the side compared with the brain of a young alligator (see pl. lxxviii). The divergent forms of the teeth are likewise shown. The pelvic bones, fore and hind limbs, are similarly treated.

Restorations of the skulls, limbs, and entire skeletons are given of *Anchisaurus colurus, Ceratosaurus nasicornis, Brontosaurus excelsus, Stegosaurus ungulatus, Camptosaurus dispar, Laosaurus consors, Triceratops prorsus,* and of *Claosaurus annectens*; whilst of European dinosaurs we have restorations of *Compsognathus longipes, Scelidosaurus Harrisoni, Hypsilophodon Foxii,* and *Iguanodon Bernissartensis.* The palatal view of the skull of *Diplodocus longus*, given on p. 177, is very interesting, and with the figures in pls. xxv and xxvi, and pl. lxxvi, fig. 4, completes our knowledge of this very strange form. Plate lix, skull and lower jaw of *Triceratops prorsus*, taken by photo-process from the original, gives us a fine idea of the head, one-ninth natural size, of this marvellous giant.

This volume, interesting though it be, with its 84 plates and 110 pages of text, is but a first instalment to a much more elaborate work which the author has in contemplation to produce. We trust that health and strength may be spared to Professor Marsh to complete this large task, and we will accept the present Memoir merely "on account," for which we are indeed truly grateful, but, like Oliver Twist, we are still "asking for more."

II.—MOVEMENTS OF BEACH SAND AND SHINGLE.

IN an article on "Littoral Drift" read before the Institute of Civil Engineers,[1] Mr. W. H. Wheeler discusses the origin and movements of the sand and shingle along sea-coasts. He maintains that the movements are practically confined to the tract between low- and high-water mark; that the contour of the sea-bed on a sandy coast, when covered with a moderate depth of water, remains in a stable condition; and that so long as the conditions remain the same, the form of the banks and depth of the channels are not altered by winds and waves. He is thus led to believe that channels can be effectively deepened and maintained on sandy coasts by the system of suction-dredging; that they will then remain stable and retain their depth. Moreover, harbours may be projected out from sandy coasts without danger of the entrance shoaling, provided that the piers are so placed as to derange the main set of the tidal current as little as possible, and are carried into a sufficient depth of water; and that where required, the supply of littoral drift is cut off by protective works along the coast.

If these views be true their great importance is obvious. In support the author points out that the main navigable channel to New York, which passes through the outer bay to the Atlantic, was obstructed by four long shoals, over which the larger class of vessels could only pass at high-water. Suction-dredging was tried;

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[1] Proceedings, vol. cxxv, 1896.

the channel was deepened so as to give a minimum depth of 30 feet at low-water over a width of 1000 feet, and a year afterwards it was reported that no shoaling had taken place. Again, the sand-bar which lies at the junction of the Mersey with Liverpool Bay has been deepened by the use of suction-dredgers, and the channel so excavated has not only maintained its depth during the severe tests of the gales of two winters, but shows a tendency rather towards deepening than shoaling. Other instances are given.

The author believes that the mass of beach sand and shingle which travels along the coast is due entirely to the erosion of the cliffs (which may, of course, consist of hard rock or of ready-made sand and shingle), and is not derived from the sea-bed. Hence he is of opinion that the quantity of drift is limited, and that it may be entirely stopped or its movement controlled, He, however, thinks that vast deposits of sand and shingle in bays and sheltered places on the coast are due to causes which occurred in remote ages, and which are no longer in operation—we presume at the localities in question. Thus, in Morecambe Bay the sand-beds cover an area of 90,000 acres dry at low-water, and in the Duddon estuary they cover 9,000 acres. The Wash covers an area of about 157,600 acres, of which about 84,000 acres consist of sand-beds dry at low-water. It is quite true that rivers add very little to these accumulations, but the waste of the coast now or formerly bounded by cliffs composed of Drift sands and other deposits has no doubt led largely to these great marine deposits.

We would point out that salt-marshes are not exactly due to the drifting of alluvial matter along tidal coasts and to its settling in sheltered places, but rather to ordinary alluvial deposits being formed in a broad valley or estuary, bounded by higher ground that has on one side been subsequently worn away by the sea. The salt-marshes along the Norfolk coast were probably formed in this way.

On the whole, while agreeing that the main contentions of the author are supported by fact, we believe that agents now at work will account for all the phenomena without recourse to higher and more frequent tides as suggested by him.

Among the matters discussed by Mr. Wheeler, we may mention his conclusion that while wind and waves are the agents which operate in eroding the cliffs and producing the sand and shingle, the regular and continuous travel of the material along the coast is due to the wave-action of the flood-tide.

In conection with these views, we may refer to those of Mr. F. P. Gulliver, given in an article on "Cuspate Forelands,"[1] or headlands formed by beach shingle and sand, and also as delta deposits. He points out that when the supply of waste from the cliffs has increased beyond the power of the currents to immediately deposit it offshore, then transportation takes place alongshore, and the growth of forelands may take place by tidal- and ocean-current action. Ocean currents have but little effect on the inner shore-line, or that of the more protected coasts of bays, sounds, etc.; there tidal currents are the preponderating force. In broad bays ocean currents, tidal currents, or local wind currents, may, according to circumstances, be the strongest. Upon the outer shore-line the ocean eddy currents are the most effective, while upon lakes and inland tideless seas the local wind currents are the most important factor. The method in which various cusps are formed is well illustrated, but the author's explanations are rendered perhaps a little difficult by an American tendency to introduce and coin new words. H. B. W.

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[1] Bull. Soc. Geol. America, vol. vii, 1896.

III.—Elementary Palæontology: Invertebrate. By Henry Woods, M.A., F.G.S., Demonstrator in Palæozoology in the University of Cambridge. Second Edition. 8vo, pp. xiii and 296, with 112 figures in the text. Cambridge Natural Science Manuals. (Cambridge University Press, 1896.)

PROFITING by the rude blasts of criticism and the equally instructive but gentler experiences gained in teaching, the author has brought out a second edition of his "Elementary Palæontology," which is a great improvement on the first, which appeared three years since. The book has been materially enlarged, a greater number of genera are described, and references are given to one or more typical species in each genus. The results of recent discoveries, such as, for example, in the Trilobites and Graptolites, have been incorporated in the work. Another important addition is in the illustrations, which have been doubled in number. They have professedly been selected for the purpose of explaining the structural features in different groups, but in some cases, as in the Ammonites, figures of typical species are given, and the value of the book would have been greater if more figures had been inserted in the text. So far from figures of fossils tending to lead students from making use of actual specimens, we are disposed to think the contrary, for it is very seldom that beginners in Palæontology attempt to compare their specimens with mere textual definitions, though they will readily do this if the descriptions are supplemented by figures. Great pains appear to have been taken to ensure accuracy in the definitions, both of the larger and smaller groups, and to those wishing to follow up the subject, the lists of some of the principal palæontological works will be of much assistance. Within its limits this book is a very serviceable introduction to the study of Invertebrate Fossils.

REPORTS AND PROCEEDINGS.

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Geological Society of London.

November 18, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On *Cycadeoidea gigantea*, a new Cycadean Stem from the Isle of Portland." By A. C. Seward, Esq., M.A., F.G.S.

The specimen described by the author was discovered a short time since in one of the Purbeck Dirt-beds, and is now in the Fossil Plant gallery of the British Museum. In the absence of any fructification, Buckland's generic name of *Cycadeoidea* is chosen in preference to *Bennettites*, although in many respects the Portland stem is identical with *Bennettites Gibsonianus*. Externally, the surface is covered with rhomboidal areas separated from one another by a projecting framework consisting of the silicified ramental tissue, which thickly clothed the bases of the petioles. The peripheral portion of the stem afforded thin sections from which it was possible to investigate the anatomical structure of the leaf-bases and ramental scales. Internally, the wood- and pith-tissues have been entirely replaced by inorganic material. The author calls attention to the preservation of a prominent apical bud covered with narrow bud-scales and capped by a mass of ramenta. No indication is found of a lateral inflorescence such as characterizes *Bennettites Gibsonianus*, and the negative evidence suggests the occurrence of terminal reproductive structures. A comparison of this fossil with recent Cycads and Ferns brings out many points of close agreement with the former; and as regards the structure of the ramenta, evidence is afforded of an interesting survival of the closer resemblance which formerly existed between Cycadean and Fern-like plants. The stem is named *Cycadeoidea gigantea.*

2. "The Fauna of the Keisley Limestone.—Part II. Conclusion." By F. R. C. Reed, Esq., M.A., F.G.S.

The author describes the Ostracoda, Brachiopoda, Mollusca, Echinodermata, and Actinozoa of the Keisley Limestone. He gives a list of fossils from the Limestone, and indicates those species which occur in the Limestone of Kildare, the *Leptæna*-Limestone of Sweden, and Stage F, of the East Baltic provinces. As a result of his researches he concludes that the fauna has a thoroughly Ordovician facies; that it is closely comparable with that of the Limestone of the Chair of Kildare, and of the *Leptæna*-Limestone, and less closely with that of Stage F, of the East Baltic provinces; that its palæontological features point to its stratigraphical position being at the base of the Upper Bala, and that it must be regarded as the locally thickened development of a bed which is elsewhere in Great Britain very thin, or entirely absent, or represented by beds having different lithological characters and a different fauna; and that the fauna has certain unique characters which mark it off from all other known assemblages of fossils in Great Britain.

CORRESPONDENCE.

LIFE-ZONES IN THE BRITISH CARBONIFEROUS ROCKS.

Sir,—In the November Number of the Geological Magazine, the Report of the Committee appointed by the British Association to study the Life-zones of the British Carboniferous rocks, contains a list of the Committee, from which the name of Dr. R. H. Traquair, who has kindly undertaken to report on Carboniferous fish, is omitted. As our Report is likely to become known to workers largely through the medium of the Magazine, I should be greatly obliged if you would kindly insert this correction.

Cambridge, *December* 5, 1896. John E. Marr.

ANOTHER POSSIBLE CAUSE OF THE GLACIAL PERIOD.

SIR,—In the discussion which took place on my paper on "Another Possible Cause of the Glacial Period," read before the Geological Society on December 2, 1896, the only serious objection to it, as it seemed to me, was one by Dr. Blanford, in which he maintained that the explanation I gave on the basis of Professor Spencer's hypothesis did not account for the extension of the Himalayan glaciers, which extension has been pointed out by Sir J. D. Hooker, and which is, in all probability, referable to the Glacial Epoch. Not having previously considered this point, I was unable at the moment to meet the objection urged by Dr. Blanford; but I suggested greater elevation of this mountain chain, which would have not only increased the cold, but would have caused greater precipitation of snow at levels on the flanks relatively lower than at present. Further consideration induces me to believe that this is a sufficient explanation, as there are good grounds for believing that such elevation actually took place in the Pliocene Period, continuing into that of the post-Pliocene. It has been made abundantly clear that at this epoch the whole region of the Mediterranean basin underwent considerable elevation, when this great inland sea was closed against the ocean by the rise of the Straits of Gibraltar into land, and when a chain of lakes connected by rivers was established from the Black Sea throughout. This was the epoch of the great migration of the Mammalia from the Europe-Asian Continent into Africa, and the formation of the causeway, now submerged, between Italy and Tunis. The epoch was one of increasing cold, and affected in the direction of extension downwards the glaciers of the Pyrenees, the Alps, and the Caucasus; and also gave rise to those of the Lebanon, first determined by the same distinguished traveller to whom I have referred above. Is it not probable—nay, is it not certain, that this great upward movement of the crust, in an easterly direction, was continued into the Himalayas, which lie almost in the same general line of upheaval? What reason have we for supposing that it stopped short anywhere between Syria and the region north of the Ganges? I know of none; and if this be admitted, Dr. Blanford's objection falls to the ground; at least, I wait for reasons to show that this is not the case.

I am glad to find that my views are gaining acceptance amongst geologists who were not present at the meeting of the Society. Professor Spencer wrote some time since that he had arrived at similar conclusions (though not published), as the necessary outcome of his own views regarding the uprising of the "Antillean Continent"; and a few days since I received a letter from Colonel Feilden, F.G.S., in which he says: "I am quite satisfied that your view is correct, that the so-called Glacial Epoch was due to some deflection of the warm current from the Polar Basin. If Professor Spencer is correct (and I have read his papers), the elimination of the Gulf of Mexico would deprive the northern half of the Atlantic of its chief heating apparatus."

EDWARD HULL.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IV.

No. II.—FEBRUARY, 1897.

ORIGINAL ARTICLES.

I.—GEOLOGY OF THE LONDON EXTENSION OF THE MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY. PART I: ANNESLEY TO RUGBY.

By C. FOX-STRANGWAYS, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THIS portion of the new trunk line to London covers a distance of about fifty miles, and runs nearly due south, crossing the towns of Nottingham, Loughborough, Leicester, Lutterworth, and Rugby. Throughout the greater part of this distance the railway is on the Trias, except the northern portion, which is on the Permian, and the southern, which is on the Lias. There are also great thicknesses of Drift met with near Leicester and between that town and Rugby, but very little in the northern part on either side of Nottingham.

Commencing at Annesley, the first section, which is just east of the Midland station, shows the lower sandstones of the Trias overlain by a little sand and gravel. This sandstone is not here of any great thickness, as in the shallow depressions on either side the Permian Marls crop out and may be followed along the next cutting to the south. At the south end of this cutting a fault is crossed which brings in the Magnesian Limestone. The railway is continued over this formation for some distance beyond Linby, but being carried on a high embankment the rock is only exposed here and there in the ditch along the side. The sections, however, show that there is not much superficial covering over this comparatively flat ground.

As we approach Hucknall Torkard there is a marl cutting, but the limestone soon rises up from below. This latter is much disturbed by a fault or sharp roll near the bridges at the north end of the town, some of the beds being quite vertical. The same disturbance was noted in the culvert over the brook a little to the south. A drawing of this was made by Mr. Allen, the resident engineer of this portion of the line.[1]

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[1] I am greatly indebted to Mr. Edward Parry and the resident engineers of the different sections of the line for much information as to the nature and thickness of the strata met with in the excavations for bridges and other structures, which were covered up before the time of my visit.

In the large cutting west of Hucknall Torkard the marls repose on the Magnesian Limestone, the whole being surmounted by about six feet of pebbly clay; but the section was not cut to its full depth at the time of my visit. At the south end the limestone is again much disturbed, and dips to the south-east at an angle of 15°, passing under the marls. There is no doubt that the stratification here is much more broken up than shown on the old geological map, and that a good deal more marl crops out than is represented there.

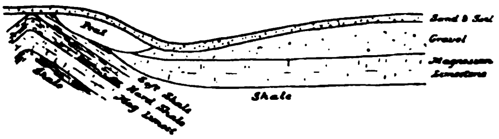

Fig. 1.—Section in culvert north of Lambert Hill, Hucknall Torkard. Copied from a drawing by Mr. Allen.

Several cuttings in marl were observed between this spot and the Leen valley, where the Permian beds pass beneath the Trias. Over this ground there also appears to be a certain amount of pebbly gravel; but, from the railway-section alone, it is not clear of how much importance these deposits are.

At Bulwell the line crosses the Leen valley by a lofty viaduct, the excavations for the piers of which exposed sections in marl and limestone on the west side of the Midland Railway, and in sandstone on the east side.

The line now enters the Trias, the sandstones of the Pebble Beds being exposed in several fine cuttings between here and Nottingham, beneath which town it is carried in a series of tunnels that were easily excavated in these soft false-bedded sandstones.

On the south side of Nottingham the piers for the bridge over the Trent were sunk through from 10 to 12 feet of river gravel on to the Bunter Sandstone, and showed that the latter was more eroded on the southern side than on the northern, the solid rock being reached at 57 feet above ordnance datum on the northern side, while it was 52·5 feet at the south abutment.

After crossing the broad expanse of the Trent Alluvium at Wilford the line enters a deep cutting in the marls of the Keuper series, and there is a good section of the band of sandstone that is shown on the old geological map dipping at 2° to the south-east. Towards the southern end of this cutting the marl is overlain by about 8 feet of sand and gravel, which appear to be banked along the foot of the hill.

At Ruddington the line crosses a depression in the marl filled with sand under about 3 feet of dark peaty soil which extends past the station. This hollow has evidently been an old swamp similar to the larger one at Gotham alluded to below. At the side of the railway here is the boring which has been recently carried to a depth of 1873 feet; this boring beneath 684 feet of Trias penetrated over 400 feet of strata, supposed to represent the lower portion of the Derbyshire Coal-measures. These were found resting on coarse grits and sandstones, probably the equivalent of the Millstone Grit.[1] South of Ruddington station there is a cutting showing from 3 to 12 feet of sand and chalky gravel, with pockets or pipes of clay overlying the marl. Beyond this the line crosses Gotham Moor, where numerous small excavations show about a foot of peaty soil over sand and gravel. It is evident that this extensive flat, which stretches from Gotham to Bunny, a distance of about three miles, was formerly a swamp or possibly a shallow lake. On the south side the ground rises in the long ridge formed by the Rhætic beds and the lowest part of the Lias; but the line passing in the hollow between the outlier of these beds and the main mass, there is no section in them, and only some whitish-grey or tea-green marls are seen reposing on Red Keuper Marl.

Opposite East Leake there is a deep cutting showing tea-green marl beneath Drift deposits, the latter consisting of sand and gravel beneath a Boulder-clay, in which there are many well-rounded pebbles of quartz and fragments of Keuper Sandstone, but very few boulders of any size. With the exception of the doubtful gravels at Ruddington, it will be observed that this is the first really glacial section that we have come to; but to the south of Loughborough they become more common and are of greater importance.

South of Leake the railway cuts through the narrow ridge of Lias and Rhætic forming Normanton Hills, and a very interesting section is exhibited in these beds. The summit of the ridge is crossed by a short tunnel, on the north side of which is a deep cut in grey or tea-green marls surmounted by about 20 feet of dark, finely laminated shales. At the junction of these there is a yellow band about 6 inches thick, but there is no bone-bed, or if there is it must be in a very fragmentary condition.[2] The beds dip at 6° to the south, and are let down against the Red Marl to the north by a fault which is seen within a few yards of the end of the cutting. South of the tunnel the lower part of the Lias comes on rather rapidly with a dip increasing from 2° to 6°. The beds, which constitute the *Planorbis*-zone, consist of the usual alternations of shales and bands of limestone with a thick bed of shale at the bottom resting on a band of nodules.

SECTION AT NORMANTON HILLS.

		ft.	in.
Thin band of limestone ...	About 2 or 3 feet, but much broken up and weathered.		
Shale			
Thin band of limestone ...			
Shale			
Band of limestone		0	8
Shale		2	0
Band of limestone		8	0

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[1] G. E. Coke: Trans. Fed. Inst. Mining Eng. 1896; Proc. Geol. Assoc., vol. xiv. p. 430.

[2] Mr. Montagu Browne gives a short but detailed account of this section—Report of the Brit. Assoc. for 1895.

	ft.	in.
Shale	3	0
Band of limestone	0	4
Shale	1	0
Sandy shale	0	10
Limestone full of *Ostrea*	0	7
Sandy limestone and shale	1	6
Shale	0	6
Band of limestone	0	8
Shale	0	8
Band of limestone	0	10
Shale	13	0
Band of nodular limestone	0	10

Towards the southern end these beds turn up rapidly at an an increasing from 10° to 25°, until at 140 yards from the centre of road over the tunnel the great east-and-west fault is crossed wh brings in the red marls of the Keuper. The Diagram gives general appearance of this section (Fig. 2).

From this point the line continues on red marl as far as River Soar opposite Loughborough, passing through a deep cutt in marl with a band of sandstone 3 feet thick dipping to north at the low angle of from 1° to 2°. The northern end of t cutting is formed of Boulder-clay resting on sands and gra The former contains quartzite pebbles and fragments of sandst and Lias, some of which are of considerable size and genera striated. The gravel is composed mostly of quartzite pebbles, occurs in pockets or irregular patches in the sand. This drift con about to the bottom of the cutting on the north side, but thins near the summit of the hill; showing that it does not cap the in the usual manner, but is deposited against its northern western flank, as we shall show is the case in some of the secti further south.

In crossing the valley of the Soar the alluvium was found vary from about 15 to 19 feet in thickness, and consisted of following subdivisions[1]:—

	ft.	in.
Soil	2	6
Loam and clay	6	0
River gravel	7 to 10	0

The thickest gravels were met with at the north end of viaduct, and near the centre; which spots probably mark position of old bends in the river. At the Nottingham Road, the Midland Railway, and at the Canal the marl was reached 8, 14, and 12 feet respectively.

At Loughborough the line crosses a terrace of chalk gravel, wh extends for some miles on this side of the Soar valley, as will shown in the new edition of the Geological Survey Map. T terrace is about twenty feet above the modern alluvium of the riv the gravel, which has an average thickness of ten feet or m is composed mainly of chalk flints and quartzite pebbles; i erived from the Chalky Boulder-r up the valley. This gravel is along the railway with some ns as far as Quorn Lodge, where inner and becomes mingled with ιy and earlier gravels, so that the re rather obscure. In fact, the ɔout here show how difficult it is ı gravels which are of late Glacial hose which are Post-Glacial. One ɔwed contorted beds of clay and its relation to the gravel was not ·om the general aspect of these am inclined to think that the ıust have been begun to be laid ediately after the later Glacial beds, a little ice was still lingering in ys.

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[1] From information supplied by the resident engineer, Mr. F. D. Sharp.

rossing the little valley west of the railway continues in Keuper we reach the hill west of the new .t Rusheyfields Lane. Here there p section in Boulder-clay, but the ·t had been sloped down before I he north end of the cutting, how-·xposed, and showed about six feet ıamy in part, with a little pebbly he bottom resting on Boulder-clay, large Lias fragments, and a few l Carboniferous Limestone blocks, the boulders, especially the Lias being striated. No chalk fragments ·ed here, although they are plentiful ıosite side of the valley at the foot ı Wood and in the branch line ·ing taken to Mountsorrel quarries. nch line there is a good section of Boulder-clay, which at the northern :Iawcliff Hill is seen reposing on .y without any chalk, there being a little sand between the two. nckley Hill the Chalky Boulder-:lirectly on the Keuper Marl, the lder-clay having thinned out in this The Chalky Boulder-clay here con-Lias and granite boulders.

kley Hill the branch railway cuts boss of granite, the junction with g beds being, as usual, very steep. ɔrn side the Boulder-clay rests on

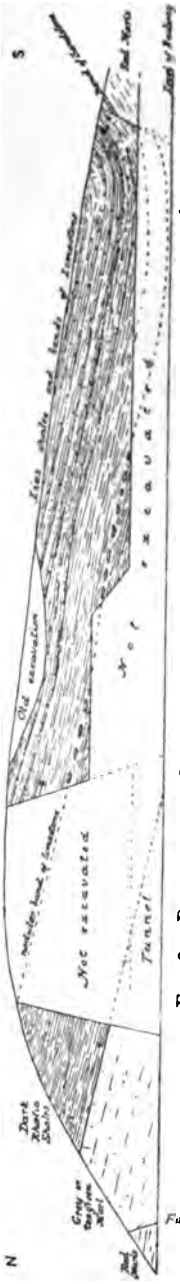

FIG. 2.—DIAGRAMMATIC SECTION OF THE CUTTING THROUGH NORMANTON HILLS.
Length of section 500 yards. Vertical scale about three times the horizontal.

the granite; but on the western side the Red Marl is seen abutting against the granite, large blocks of the latter being included in the marl as if they had fallen from a cliff during its deposition. The main railway also just touches the granite of Brazil Wood, but there is no section of the rock;[1] the piers of the viaduct, however, are sunk in Keuper Marl, showing again how steep the junction is between these two formations.

After crossing the road to Swithland, the line enters some thick beds of gravel and sand, which underlie the great spread of Chalky Boulder-clay forming Rothley Plain. This sand, which is stratified, contains numerous isolated boulders of granite, many of which are of considerable size, but there do not appear to be any other stones in the main mass of the sand, nor any clay. The appearance of these great boulders sticking out in the sand is most remarkable, and how they got there is a curious problem. Possibly they are evidence of a granite cliff in the immediate neighbourhood; the absence of any clay seems to preclude them from being due to glacial action. At the summit of the hill these sands pass beneath a thin covering of Boulder-clay, and at the bridge under the road to Rothley terminate very abruptly against a bank of Keuper Marl, another instance showing how these drifts seem to be banked against the northern sides of the hills.[2]

On the opposite side of the Rothley valley the line passes through a deep cutting in Boulder-clay, which is mainly composed of Lias with quartzite pebbles and some chalk fragments. It also contains irregular patches of sand and gravel, but no beds of any thickness. This same Boulder-clay, which, however, becomes more chalky, continues for about two miles to the neighbourhood of Birstall. Here at the back of Cliff Lodge the Boulder-clay contains masses of very coarse gravel composed mostly of Lias and Oolite, which has been pushed into a series of undulations between masses of Boulder-clay, evidently showing some disturbing force subsequent to its deposition. At Birstall Hill Park a thick bed of sand and gravel comes out from beneath the Boulder-clay, and, rising to the south, soon occupies the whole of the cutting, forming one of the finest sections of false-bedded sands and gravel to be seen along this part of the railway. There is not much doubt that this sand is part of the bed which occurs at the base of the Boulder-clay in this country, and which has been traced almost uninterruptedly along this side of the Soar valley; but its position here is rather abnormal, being considerably above the usual level of these sands. Before the cutting was made there was very little evidence at the surface of so large a deposit of sand and gravel.[3]

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[1] A short account of the rocks near here is given by Mr. W. W. Watts: Trans. Leicester Lit. and Phil. Soc., vol. iv, p. 12, 1895; and Proc. Geol. Assoc., vol. xiv, p. 432.

[2] At this spot some supposed British remains have been found by Mr. W. T. Tucker, who gives a beautifully illustrated account of them in the Trans. Leicester Lit. and Phil. Soc., vol. iv, p. 212, 1896.

[3] Mr. Montagu Browne, F.G.S., has some fine photographs of these gravels.

At the southern end of this cutting just above the Belgrave Cemetery there is an opening in the usual Lower Boulder-clay of the district composed of Lias and other local rocks without any chalk fragments.

The railway crosses the Mowmacre Road on a lofty embankment, the foundations of the bridge showing a very steep boundary to the Keuper Marl at the side of the valley, the south abutment being against the marl, while the northern one was sunk 16 feet in loamy sand without reaching the bottom of it.

In the next cutting the lower non-chalky Boulder-clay was found in the foundations of the bridge over the path to Stocking Farm. A little further on there is a section in the clays and gravels above, which is interesting from the close similarity of one of the bands to certain beds in the Coal-measures; leading one to the idea that, although these beds were formed under very different circumstances, some of the conditions may have been somewhat similar. The clay, which was somewhat of the nature of "clunch," that is, a firm marly clay without much stratification, contains lines of incipient concretions, which appear to be in process of formation. The following sketch will show the relations of the beds more clearly :—

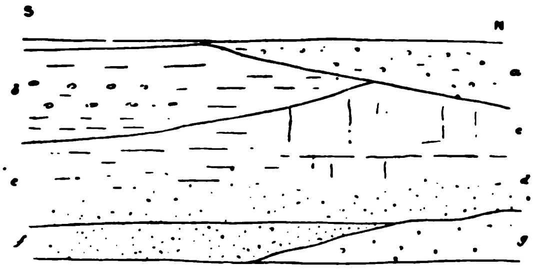

FIG. 3.—CUTTING S.E. OF STOCKING FARM, NEAR LEICESTER.

(*a*) 4 ft. Weathered Boulder-clay with scattered chalk flints. (*b*) 6 ft. Irregular, lumpy, soft, marly beds, and clay with incipient concretions. Has very much the appearance of unconsolidated Coal-measure clay. (*c*) 3 ft. Stiff dark clay. (*d*) 3 ft. 6 in. Loamy sand. (*e*) 5 ft. Sand and loam with marly partings containing lime. Passes into dark brickearth and drab clay towards the north. (*f*) 2 ft. Chalky gravel. (*g*) 3 ft. Gravelly, chalky Boulder-clay.

The sand and gravel at the base crops out on the side of the hill, and is continuous with the general outcrop of these beds throughout the district.

After crossing the little valley leading up to Beaumont Leys, which is on Keuper Marl, the line traverses the extensive plateau of gravel on which Leicester Abbey stands, and which fringes the river Soar at this point. In crossing the river the Red Marl was found at a depth of a little over 10 feet, but further on, between the river and canal at Slater Street, the depth was over 18 feet, showing that the old course of the river must have formerly been further south at this point.

Through the courtesy of Mr. Chalcraft, the resident engineer of this portion of the line, we have obtained a large number of sections in the town of Leicester. These seem to show that the rise of the ground to the south of Soar Lane, although based upon marl, is mainly caused by the great accumulation of made ground which occupies the site of the old Roman city. This deposit is in many cases fully equal to the rise of the ground ; in Bath Lane it appears to sink below the level of the river, showing that the contour of the ground and probably the position of the stream have altered considerably since Roman times.

After again crossing the river at West Bridge the railway continues for some distance over the alluvium, which was found to be of varying depth up to 20 feet at St. Augustine Street. On the west side of the Bede House Meadow the foundations of the viaduct showed that this alluvium rests abruptly against a steep bank of Red Marl. Entering a cutting of Red Marl we find at its southern end an equally abrupt termination, a terrace of sand and chalk gravel being banked against the marl. This same gravel is seen again under the Burton branch of the Midland Railway, where it is also banked against marls to the south; but is partially overlain by dirty gravel and sand, which evidently belong to the Glacial beds. The section appears to show that the drift gravel is more recent than the banked terrace below, but this is probably not the case, and as the gravel does not extend far it may have slipped over the edge of the terrace. Further on in this cutting, just beyond St. Mary's Mills, there is a thick deposit of cemented gravel, which has aroused a good deal of local interest and speculation as to the source of the cement, although such gravels are really not at all uncommon. They are excessively hard, and have given the contractor a good deal of trouble to excavate.

The line now for the fourth time crosses the Soar valley, the alluvium of which was found to be from 6 to 12 feet thick. South of Aylestone there are cuttings showing from 8 to 20 feet of local drift composed chiefly of Lias and Keuper fragments with pebbles and a few granite boulders. This is surmounted by chalky clay in the deeper cuttings, but there is evidently a good deal of the non-chalky clay about here.

In sinking for the piers of the viaduct across the valley at Whetstone, there was found to be 10 feet of alluvium. Beyond this the railway is carried on a lofty embankment past the villages of Whetstone and Cosby, a distance of over two miles, before there are sections of any note. In crossing the Midland Railway at Cosby, which runs in a deepish cutting, the Boulder-clay was found to extend to the base of the foundations some depth below the rails, so that it is evident the drift must be of considerable thickness about here. This also is shown by the series of deep cuttings that are continued for some distance to the south, and in none of which the solid rock was reached.

In the cutting under the Lutterworth Road the Boulder-clay rests on sand; which, rising to the south, forms a considerable outcrop, but along the railway is soon succeeded by stiff, chalky, and local ɪr-clay. About a mile further south this Boulder-clay is seen roughly interstratified with beds of sand and warpy clay run down towards the north.

approaching Dunton Basset we come to one of the deepest ;s in this part of the line, but from the sloping down of the as the work was being carried on it was not easy to see the ·elationship of the beds. At the northern end, however, near ıd to Ashby Magna, there is an extensive outcrop of sand, is banked against or rests on the Boulder-clay further south. ·oulder-clay is of the usual chalky character, but is remarkable ts containing a large mass of Middle Lias limestone crammed *Rhynchonella*, which measured 12 feet across, and of which were exposed above the rails; how far it may have extended other directions could not be seen. At the tunnel under the ıere is a fine section showing about 35 feet of yellowish r-clay resting on 13 feet of sand and gravel. This gravel, dips to the north, is better exposed on the south side of ınel, where it crops out and is seen to be succeeded by a band and then more sands and gravels. These gravels are very arly stratified, and are composed mostly of chalk flints and ı. They must have a considerable thickness just here; and, ng the band of clay, cannot be less than 50 feet or more.

'otes de Val 19 feet of a very hard chalky Boulder-clay were in the foundations of the bridge, and at the next bridge g the road to Gilmorton there were 17 feet of gravel, showing ere are many variations in the beds, but the cuttings do not ɪny light on their relation. This chalky clay, which contains quantity of Lias and sandstone boulders, as well as a few iferous limestones, extends all the way to Lutterworth, we reach another great deposit of stratified sand and gravel. gravels have been proved to a depth of 40 feet; they contain of chalky clay, and appear to abut against the Boulder-clay west in a somewhat abrupt manner.

foundations of the bridge over the stream at Lutterworth nk through 10 feet of alluvium into beds of grey shaly Lias ɔne. I could find no fossils in this limestone, so am unable what horizon has been struck here; but the section is ɪting, as this is the only point at which the underlying have been met with between the Soar valley at Whetstone ıe Avon at Rugby.

the road just south of this bridge 2 feet 6 inches of "Red ' was found over 15 feet of sand. I did not see this section, r. Collinson, the resident engineer, states that it was exactly .euper Marl; if so, it must have been a drifted mass. Above ɔmes a Boulder-clay with seams of sand, and at the top of the bout 15 feet of gravel and loam with many chalk fragments, few large Jurassic boulders. South of Lutterworth there are w cuttings in Chalky Boulder-clay with a little sand and here and there for a distance of two miles, but no sections y importance. At Shawell the cutting shows stiff blue

Boulder-clay, with Lias and Chalk fragments resting on sands and coarse gravels, which crop out to the south, but run down under the Boulder-clay towards the north. The junction between the two is very irregular, the sand forming arches beneath the clay.

After crossing the Watling Street the line enters a thick deposit of chalky gravel and sand, which is partly cemented into a hard conglomerate similar to that mentioned above near Aylestone. This conglomerate must be fairly extensive about here, as it has been met with in a series of trial borings on the other side of the valley near the Watling Street. In the deeper part of the cutting near Newton this gravel is overlain by about 20 feet of grey Liassic Boulder-clay, which appears to turn into coarse gravel at the southern end. The outcrop of the gravel is very clear about here, and there is a sharp junction with an underlying Boulder-clay. In the cutting due east of Newton House another large boulder has been touched; it consists of a mass of yellow Oolitic limestone 15 yards in length.[1] The Boulder-clay also contains a curious ball of sand, which is concentrically stained and looks very similar to a concretion in harder rocks. Between this point and Rugby the line keeps on Chalky Boulder-clay, but there are no sections of any importance.

In crossing the valley of the Avon opposite Rugby station the blue Lias clay was found at a depth varying from 5 to 17 feet below the surface of the alluvium, and showing three or four depressions where the old streams have hollowed out channels in the solid formation. The deepest part of the old valley appears to correspond with the present course of the River Avon; but there is another deep channel 530 yards to the south of this, and 250 yards south of the present Clifton Brook.[2] The alluvium consists mainly of clay and loam, except towards the southern side, where there is a considerable amount of gravel, 15 feet 6 inches in one of the excavations.

On the south side of this valley the line cuts into the great plateau of gravel and sand upon which Rugby stands, and which has a maximum thickness of 22 feet, but in some places is not more than 3 feet thick. These gravels are of a fairly uniform character; they extend to the brow of the hill just beyond the Dunchurch and Hilmorton Road, where they form a sharp bank overlooking the Lias valley beyond. They appear to rest directly on the Lias shales below throughout the greater part of the cutting; but whether a Boulder-clay intervenes in some places was not clear, as a great part of the ground had been sloped down. From these shales the following species, which have been determined by Mr. E. T. Newton, were obtained: *Ammonites obsoletus*, Simp., *Am. bifer*, Quenst., *Am. trivialis*, Simp., *Am. curvicornis ?* Schlön., *Belemnites breviformis*, Voltz., and *Nautilus*.

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[1] This is only about a mile from Brownsover, where something of the same character was met with by Mr. J. M. Wilson.—Quart. Journ. Geol. Soc., vol. xxxi, p. 355.

[2] From information supplied by Mr. A. W. H. Carson, the resident engineer.

These seem to show that the beds here belong to the *Oxynotus* or *Armatus* zones.

South of this great cutting the line runs on an embankment for some distance, and there are no exposures till we get to Willoughby; from which point southwards the sections have been examined by Mr. H. B. Woodward, and will be described by him in the second part of this paper.

II.—On the Age of the Morte Slate Fossils.

By J. W. Gregory, D.Sc., F.G.S.

As the discussion at the Geological Society on Dr. Hicks' paper "On the Morte Slates and Associated Beds in North Devon and West Somerset" (Quart. Journ. Geol. Soc., vol. lii, pp. 254–272, pls. x, xi) showed that the case for the Silurian age of those beds rested mainly on the palæontological evidence, I examined the more important fossils somewhat carefully at the close of the meeting. I had a perfectly open mind as to the age of the fauna, for a couple of visits to North Devon and West Somerset had given me the impression that pre-Devonian beds might be hidden in the eastern part of the area. As a paper recently read to the Geological Society of Cornwall assumes the Silurian age of the Morte Slates to be so well established that it may be accepted as the basis for future work, I have been led to re-examine the evidence by a comparison of Dr. Hicks' descriptions and Mr. Michael's figures of the fossils and my notes about them.

The palæontological section of Dr. Hicks' paper enumerates eight species, while another name is added in the explanation of the plates. Of the nine species four are described as new, and five are identified as Silurian species; but in three cases the identification is queried, leaving only two species certainly claimed as Silurian.

The evidence of six of the nine species does not seem to me to be worth much. Two of the new species belong to genera having so wide a range as *Lingula* and *Spirifera*, and thus their evidence as to the age of the rock in which they occur is not very weighty. The occurrence of *Cardiola interrupta*, Sow., in the Morte Slates rests apparently on a few shell fragments, which unquestionably came from some bivalved animal, and probably from a lamellibranch. But the ornamentation shown in the specimen figured (Hicks, op. cit., pl. xi, fig. 19) agrees so closely with that of some Devonian species of *Pterinopecten* and *Aviculopecten*, that the material is quite insufficient to determine the family to which the fragments belong. In the case of the specimens figured as *Rhynchonella Lewisi*?, Sow., *Rhynchonella Stricklandi*?, Sow., and *Orthis rustica*, Sow., the specimens figured have a resemblance to the species named; but they are also very similar to Devonian species, and Dr. Hicks' queries after the names of the two first show that no great stress can be laid upon them. The identification of *Orthis rustica* is apparently based on the ornamentation; but the plan of ribbing quoted as "one of the chief characteristics of *Orthis rustica*" occurs also in the Devonian *Orthis interlineata* and in other species.

Without the opportunity for a careful study of a considerable series of specimens in various conditions of distortion, the specific determination of crushed specimens of *Rhynchonella* and *Orthis* is not a task lightly to be undertaken. I was accordingly more interested in the generic determination of the three remaining species.

The species named *Pterinæa Mortensis* is interesting as containing the most recognizable fossils in the collection. Of the two specimens figured, that illustrated by pl. xi, fig. 16 seems to me the better. Its umbo is situated at $\frac{6}{13}$ of the length of the hinge-line from the anterior end; in *Pterinæa* the umbo is much more forward, occurring at about only half that distance from the anterior end. Thus, taking the distance of the umbo from that point at 1, then in six casually chosen species of *Pterinæa* the length of the hinge-line would be as follows: 4·1, 4·4, 5, 5·1, 5·4, and 6·1. In Dr. Hicks' two species the length of the hinge-line would be 2·17 and 2·6.

Moreover, the umbo of Dr. Hicks' specimens are higher than in *Pterinæa*, and the form of the shell is pectinoid, rather than having the trigonal shape of *Pterinæa*. All the known characters of Dr. Hicks' new species seem to me to indicate that the fossils should be removed from the family Pteriniidæ, and included in the genus *Aviculopecten*. Taking ten species of that genus at random, the relation of the position of the umbo to the length of the hinge-lines varies from 1·9 to 2·5; the figures are as follows: 1·9, 1·9, 1·94, 2·02, 2·15, 2·17, 2·18, 2·25, 2·3, and 2·5. The fact that Dr. Hicks' specimens agree in this important character with *Aviculopecten* rather than with *Pterinaa*, may be regarded as due to the distortion of the specimens. This argument might be applied to the specimen shown on pl. xi, fig. 17, but in the case of the other (fig. 16) the fossil has only been somewhat lengthened; and as the lengthening has been uniform, this could not have altered the relative position of the umbo on the hinge-line. The genus *Pterinæa* occurs both in the Silurian and Devonian systems; but *Aviculopecten* is typically Upper Palæozoic.

In the next species, *Modiolopsis Barricanensis*, Hicks, the generic determination is again the important point. The species is said to approach most nearly to the Silurian *Modiolopsis subalata*, Hall; but the resemblance between the two species does not seem to me very striking, and, in fact, I doubt if they belong to the same genus.

There are two specimens figured as belonging to this species; that shown on fig. 15 is too young for determination by itself, but the other specimen is more instructive. It is probably a member of the family Modiolopsidæ; but all doubt on this point cannot be removed without further exposure of the anterior margin of the shell. Assuming that it is one of the Modiolopsidæ, it seems to me to belong to *Modiomorpha* rather than to *Modiolopsis*. The distinction of the two genera rests on the dentition, which cannot be seen in either specimen; the affinities of the species can therefore only be provisionally determined by comparing its form with that of the variations seen in the two genera. The larger specimen of Dr. Hicks' new species agrees fairly closely with the Devonian species *Modiomorpha subalata* (Conr.); and the probabilities seem to be that if the dentition be ever determined, the fossil will be found to belong to the Devonian genus *Modiomorpha* rather than to the typically Silurian genus *Modiolopsis.*

Dr. Hicks lays most stress on the specimens determined as *Stricklandinia lirata*, Sow., of which he has figured four examples, viz., fig. 3, p. 267; and pl. x, figs. 6, 7, and 8. Of the four specimens, that shown on fig. 8 may be left out of account, as it is a smaller and less satisfactory specimen of the form shown in fig. 6, with which it fully agrees; while that drawn on pl. x, fig. 7 has lost the upper part of the shell, so that its family position is indeterminable; the dotted line on the plate which suggests the position of the hinge-line and beak is hypothetical.

The two remaining specimens show three characters—

1. The hinge-line is recognizable in the specimen shown in fig. 3, although it is not seen in the figure; the hinge-line is straighter than in the genus *Stricklandinia*, and agrees rather with *Orthotetes.*

2. The muscular impressions. A pair of scars are shown on pl. x, fig. 6, which Dr. Hicks identifies as muscular impressions. If this be correct, it tells strongly against the fossil being a *Stricklandinia*, for the muscular scars are far too large and wide; they agree with those of *Orthotetes*, especially with those of the subgenus *Hipparionyx.*

3. The shape of the shell. The specimen that offers the most reliable evidence as to the shape of the shell is shown in pl. x, fig. 6. The specimen is much higher than it is broad (ratio 18 : 11); whereas in adult *Stricklandinia lirata*, the ratio of height to breadth varies from 18 : 22 to 18 : 26. The fact that the height of the Morte Slate specimen is twice as great as in *Stricklandinia lirata*, may be explained as due to crushing. But if the height of the shell has been increased and its width decreased by deformation, then the muscular scars also must have their breadth decreased by deformation. They are, however, already far too wide for *Stricklandinia*; so to include the Morte Slate fossil in that genus, we must assume that the crushing of the specimen rolled out the shell in one direction and the muscular impressions at right angles to that direction.

The evidence of the two specimens (fig. 3, and pl. x, fig. 6), therefore, appears to me conclusive that they do not belong to *Stricklandinia.* To what genus, then, do they belong? There is a striking resemblance in form and in the nature of the muscular impressions, as well as a general agreement in size and hinge-line, between these specimens and that figured by Davidson as *Orthis hipparionix* in his "Devonian Brachiopoda," pl. xvii, fig. 8. The specimen shown in that figure belongs to a species which is probably allied to one previously figured by Davidson (loc. cit., pl. v, fig. 8) as *Spirifera disjuncta* var. *gigantea.* Davidson so named that figure from the belief that his specimen was identical with the form named by Sowerby *Spirifera gigantea.* In this Davidson appears to me to have been in error. Sowerby's specimen was a *Spirifera*, whereas the specimen which Davidson confused with it is either an *Orthotetes* or an *Hipparionyx*. The mistake was unfortunate, for it continued the union of two distinct species under the name *Spirifera disjuncta*, one of which, as Professor Hughes suggested, is the same or a very close ally of the Morte Slate fossil.

The specimen of "*Spirifera disjuncta* var. *gigantea*" came from Tintagel, and that of the *Orthis hipparionix* from Looe. It would be rash to found any argument on the specific relationships between these forms and Dr. Hicks' fossils. But if I had to give the last a name, I should, without much hesitation, call it *Hipparionyx* aff. *proximus*, Vanux, and regard it as also closely allied to *Orthis hipparionyx*, Dav. *non* Hall, and to *Spirifera disjuncta* (*pars*), Dav., var. *gigantea*, Dav. *non* Sow. If I am right, the affinities of the species are decidedly Devonian.

Dr. Hicks is warmly to be congratulated on the success which has attended his persevering and painstaking search for fossils in such unpromising material as the Morte Slates; and every geologist interested in the Devonian question will feel grateful to him for his addition of this interesting fauna to the materials available for the solution of that problem. The determination of crushed casts of fossils is a task which is always difficult, but is often necessary, and fortunately is frequently possible. The truth is generally reached in such cases by a series of suggestions, of which one after another is shown to be incorrect. Accordingly, the publication of this note may help in the final determination of the age of the Morte Slates, even though its conclusion that the affinities of the fauna are Devonian rather than Silurian be proved erroneous.

III.—NOTE ON BRITISH GEOLOGICAL PHOTOGRAPHS.

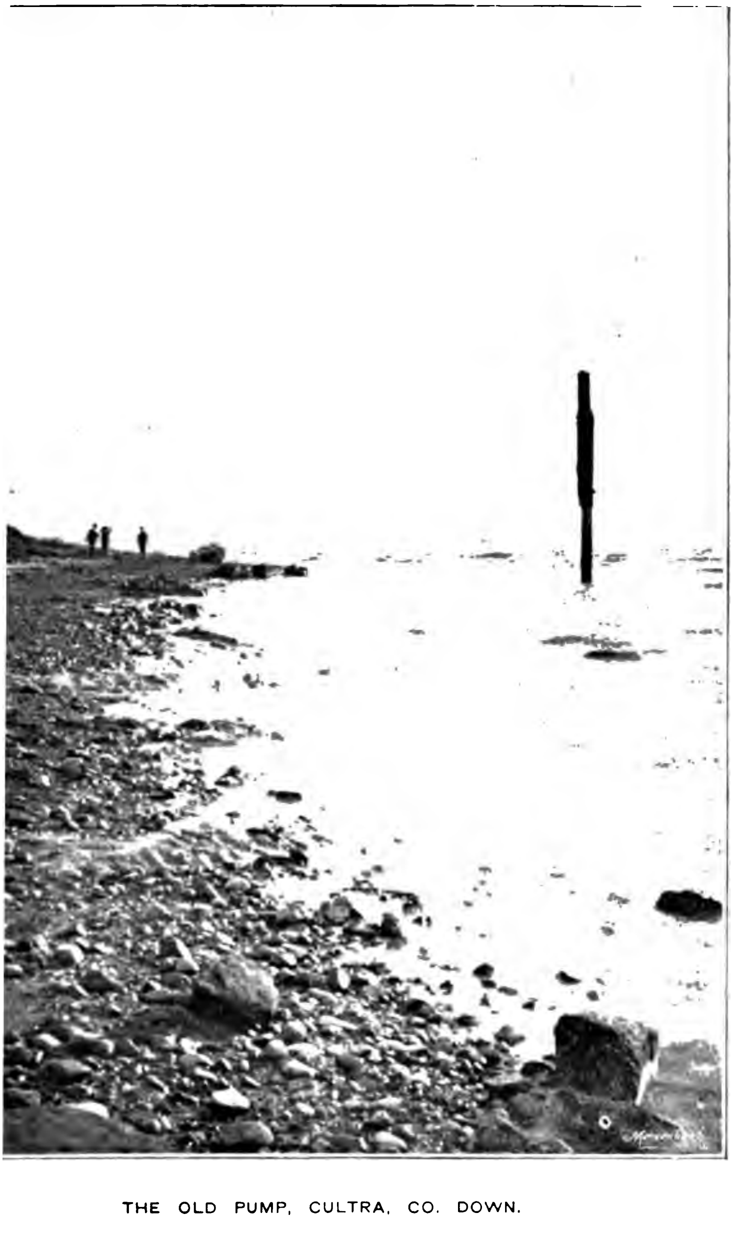
By W. W. WATTS, M.A., F.G.S.

(*Continued from the January Number, page* 37.)

(PLATE II.)

IN illustration of the article on this subject published in last month's GEOLOGICAL MAGAZINE, three plates have been prepared by the kind permission of the photographers, and of the editors of the publications in which they originally appeared. One (namely Plate II) is now issued, and Plates III and IV will be given in the March number.

Plate II, which has been lent by the publishers of *The Irish Naturalist* for January, 1893 (vol. ii), by kind permission of Messrs. G. H. Carpenter and R. Lloyd Praeger, represents the remains of a windmill pump photographed by Miss M. K. Andrews. This was erected in 1824 or 1825 to remove the water from an old quarry, and in 1829 is known to have been 50 feet from the sea. It was, when the photograph was taken, 50 feet outside high-water mark, and Miss Andrews informs me that it was completely washed away by the great storm in December, 1894, so the photograph is the only record that we possess of it.



THE OLD PUMP, CULTRA, CO. DOWN.

(*Photograph by Miss M. K. Andrews, in the* IRISH NATURALIST, Vol. II, *No. 1 (1893), Pl. I.*

IV.—THE "GREAT SUBMERGENCE" AGAIN: CLAVA, ETC. PART II.

By DUGALD BELL, F.G.S.

LAST month I glanced at some of the difficulties attaching to the theory of a "great submergence" during Glacial times, particularly in connection with the deposition of this shelly clay at Clava.

In regard to the alternative theory of transport by land-ice, the following facts may be enumerated as so far in its favour:—

(a) Evidences of ice-action are conspicuous all over the district. It is a region of intense glaciation, and this special locality is right in the tract of the ancient ice-sheet.

(b) The traces of the movement show that, with a very small submergence, the ice-sheet must have passed over part of a former sea-bottom.

(c) That in this neighbourhood it *rose* in its progress, carrying numerous boulders with it in its course, and leaving them at higher elevations than their parent beds of rock.

These facts, we submit, give a *primâ facie* probability to the ice-transport theory—to this extent at least, as showing that it does not assume an agency or condition of things which cannot otherwise be shown to have existed. The agency and conditions it assumes are clearly made out to have been in force in the place and at the time, and to have acted in the direction and on the scale, required.

Has the submergence theory, on the other hand, any such independent evidence to support it? Mr. Smith, for example, assumes "deep, still water" at Clava, implying a total submergence of about 1000 feet; and to this he adds "surface-currents carrying thin shore-ice" laden with mud, stones, shells, etc. What is there to support all these hypotheses? Apart from the difficulty raised by several eminent physicists as to the likelihood of there being any ice at all in this country, with such a submergence, we ask where are there any traces of the assumed shore-line, at 1000 feet above the present sea-level, from which the hypothetical "shore-ice" started? Are there no fragments of it among the hills of the district, or anywhere over the country? Is the whole thing a series of suppositions made to suit this particular case—resting on nothing—hanging, as it were, in the clouds? At this rate, one can imagine anything—even (as has been done) immense changes in the distribution of sea and land, three or four times repeated, to explain some purely local phenomena!

Let us look now at some of Mr. Smith's objections to the theory of the shells, or shelly clay, having been transported by land-ice, merely premising that the many instances in which this theory is undeniably true constitute a probability in favour of its being true in this instance also.

(1) So far as has been observed, there are no striations on the shells; and "it is physically impossible," says Mr. Smith, "that the shelly clay with stones, or even the shells" could have been transported by land-ice without being striated. They might, indeed,

have escaped striation by being carried on the surface of the ice; but "the shelly clay," Mr. Smith kindly informs us, "cannot possibly have fallen on the surface of the ice, neither could it have been carried up *under* it without many of the shells (if not all in this case) having been striated." Therefore it is "physically impossible."

We may remark that men of science are in general rather chary of saying what is "physically impossible," or not impossible, and the most capable are the most chary. It is awkward to pronounce anything "physically impossible," and then find out that somehow or other it has been done!

In the present instance, besides being carried *on* the ice, or pushed along *under* it, may not shells, etc., be taken up into the mass of the ice and encased and imbedded *in it*, and so transported considerable distances uninjured? Mr. Lamplugh, in one of his admirable papers, has said that while he cannot fully explain how the ice has done this, he has no doubt of the fact. He has found the most delicate shells uninjured in the transported clays of the north-east of England; and in the Boulder-clay of British Columbia he discovered shells actually more perfect than those he could pick up on the existing beach. In the same way Mr. Mellard Reade has noticed the occurrence of long thin slabs of chalk in the Boulder-clay of Cromer, and marvelled how they could have been transported entire or without being shattered to pieces.[1] And Dr. James Geikie has remarked that boulders once imbedded in the ice may be carried for "a hundred miles without suffering abrasion."[2]

Thinking the matter over, it has occurred to the present writer that wherever the ice-sheet passes from a deeper to a shallower part of its bed it has probably a tendency to insinuate itself beneath anything resting on the slope up which it is moving, and lift or *lick up* such things (as stones, shells, masses of shelly clay) into itself, and so carry them forward and upward with it. Thus the Loch Lomond ice, passing from the deep part of that loch to the shallower part, caught up numerous marine shells (the relics of a preceding *moderate* submergence) and deposited them with the till in the neighbourhood of Drymen. The Moray Firth ice, passing on to the mainland of Caithness; the Irish Sea ice, impinging on Moel Tryfaen, and the Loch Ness ice in its course towards Clava, seem all to be instances of the same kind.

But whether this suggestion be accepted or not does not alter the fact. If Mr. Smith asserts that it is "physically impossible" we would ask him to say how he knows. If by observation, where and how were the observations conducted? if by testimony, who are his authors? if by intuition, there we must leave him.

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[1] Q.J.G.S., vol. xxxviii.

[2] "Great Ice Age," 3rd edition, p. 204.—A good example of how materials may be conveyed with very little injury when imbedded in the ice (in whatever way they got there) is furnished by the well-known sad incident of Dr. Hamel's three guides, who lost their lives by being swept by an avalanche into the *berg-schrund* of the Glacier des Bossons, Mont Blanc, in 1820. In 1861 the glacier, near its lower extremity, gave back the remains of what it had swallowed up forty-one years before. "Scientific instruments, knapsacks, gloves, etc., were gradually set free from their icy fetters. A *gauze veil* came out untorn and not much faded; and the knapsack of Pierre Carrier contained a *leg of mutton* perfectly recognisable!" (See "Le Mont Blanc," by C. Durier, and Main's "My Home in the Alps," p. 68.)

(2) Mr. Smith states that if the shelly clay had been deposited by the ice in an extra-glacial lake (as the present writer supposed) "it ought to have contained abundance of vegetable matter, fresh-water mollusca, fresh-water diatoms, fresh-water Ostracoda, etc." In reply to this it was pointed out, when Mr. Smith read his paper to the Glasgow Society, that such glacial lakes are notable for the absence of organisms of any kind, for the azoic character of their sediments. Such instances were referred to as the Merjelen See in Switzerland, the beaches of the old glacial lakes in Glen Roy (which, because they do not contain fresh-water organisms, some argue must be marine, not seeing that there is a greater difficulty on that side in the total absence of marine organisms), and the mud or clay deposits of the old glacial "Lake Humber," traced out in England by the late Professor Carvill Lewis, which, he remarks, is "entirely devoid of traces of animal life, and the only bodies of water known to be so are lakes bordering on glaciers."[1]

These facts, we say, were pressed upon Mr. Smith's attention when his paper was read. Are they not relevant, or of importance as bearing on the point in hand? Why, then, does he not meet and answer them, instead of simply passing them by and repeating his original assertion, which they disprove? Does he imagine he can carry his case by sheer reiteration? Apparently![2]

(3) In some respects, it must be admitted, Mr. Smith's "interpretation" of the section is original. He deals largely in hypothetical "currents," and manipulates them as "surface" or "bottom" currents according to his requirements. Thus we are told: "The Clava shelly clay says—'*I am a mud; there were no currents flowing where I was laid down.*' . . . It is a deep-water deposit formed in the sea where there were no *bottom* currents. . . . It was formed in deep water by *surface* currents." On the other hand, the bed of fine sand overlying it, 20 feet in thickness, was "formed by *bottom* currents." (Geol. Mag., November, 1896, pp. 500–2.) Mr. Smith reads it all off as easily as Dr. Hornbook rattled over the Latin names of his medicines—"like A B C." But let us consider. How do we get these surface and bottom currents so conveniently? Between these two members of the series—the fine clay and the overlying sand—was the land "hitched up" some 700 or 800 feet, so that what was

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[1] H. Carvill Lewis, "Glacial Geology of Great Britain," p. 58.

[2] Another matter of complaint which we have against Mr. Smith is in regard to a foolish trick he has of *exaggeration*. Thus he says: "In the Clava case the marine material would require to have travelled *over* '*hill and dale*' some ten miles." (See Geol. Mag., November, 1896, p. 500.) Now, in previous papers it was pointed out that the slope from the level of Loch Ness to Clava is exceedingly gentle; that this is a feature which strikes one from various points of view in the neighbourhood; and that a rise of 500 feet in ten miles, or one in a hundred, is so small as to be practically imperceptible. Those statements no doubt Mr. Smith has read, and he makes a show of having "regard to facts." Why, then, does he lay on with the *big brush* "over hill and dale"?

a "surface current" in the one case became a "bottom current" in the other? And was this a *sudden* catastrophe? With what immense displacements of water, huge "waves of translation," etc., it must have been accompanied! How did the fine clay (which says "*I am a mud*") escape in such a turmoil? Or was it—as seems on the whole more likely—a *gradual* operation, extending, perhaps, over tens of thousands of years? (We are arguing on the supposition that there was such a submergence and re-elevation, which we do not believe.) Then will Mr. Smith please to remark that in the gradual re-elevation of the land, all his "deep-sea deposits" would successively be placed in the condition of shallow-water and shore deposits again. And if, in his own words, "the shore waves constantly agitate the material they come in contact with, washing out the mud and forming gravels and sands" (p. 501), then what chance had his fine clay (which says "*I am a mud*") of being preserved—exposed, as it must have been for an indefinitely long period, to the shore waves of the Northern Sea and to the powerful currents that swept to and fro through the Great Glen? We can, indeed, hardly imagine a more unlikely place than Clava for the existence of "still water" at any time, or for such deposits as these fine clays and sands being preserved.

(4) Touching, in conclusion, on another subject, Mr. Smith thinks "there is ample proof that they [the Boulder-clays of Ayrshire] are marine deposits." From his examination of them he says he is "finding additional proofs of the *whole drift formation* having been deposited in the sea." We have already expressed a *caveat* against rushing to conclusions in that matter (Geol. Mag., July, 1896), which, though it has not been much attended to as yet, we hereby beg to repeat. The shells, of which "the great bulk occur as fragments, although there are some very good specimens," are found in the usual Boulder-clay (or clays) of the district, and in certain associated sands and gravels, evidently "washes" therefrom. These boulder-clays are of the ordinary massive, unstratified kind, showing, it is true, here and there traces of bedding, with thin layers of sand and gravel, as in all other boulder-clays, but no regular and continuous stratification. They take their colour and composition chiefly from the immediately underlying or adjacent strata; but they contain, mingled with the rocks of the district, a considerable proportion of far-travelled blocks from the Highland mountains to the north-west *on the opposite side of the Firth*. These characteristics, we submit, mark them as undoubted glacial deposits, which cannot be accounted for by the action of shore-ice (thick or thin), pack-ice, icebergs, or floating ice of any kind. Besides, all floating ice requires currents; and our powers fail us in trying to conceive of a set of marine currents diverging from the West Highland mountains—westward to the Sounds of Lorne and Jura; eastward by the central valley to the Firth of rth; and south-south-eastward, across the Firth of Clyde to the ys and recesses of the hills in Ayrshire.

⁂ In an article by Mr. Mellard Reade on the "Present Aspects of Glacial Geology," which appeared in the December number of this Magazine, there is the following note:—

> "Mr. Dugald Bell, previous to the discoveries of Mr. Smith in Ayrshire, threw such doubts upon the recorded instances of the occurrence of shells in the Drift of the South of Scotland that the stock example of Chapelhall, near Airdrie, which was supposed to prove a submergence of about 500 feet, was omitted in the last edition of Dr. James Geikie's well-known 'Ice Age.' A committee with Mr. Dugald Bell as a member re-examined the locality, with a result entirely *negative*. This is only another instance of the futility of *negative* evidence, for, as we see, not long afterwards evidence of the most conclusive sort of the presence of sea-shells in natural sections open to the world were found in Ayrshire up to double the height." (Geol. Mag., December, 1896, p. 549.)

There are several points here.

1. The doubts expressed regarding Chapelhall—referring to the narrowness of the basis of evidence on which it rested, and the probability of the clay not being *in situ*—belonged to that case in itself, and are wholly unaffected by anything discovered elsewhere, whether before or since. The same doubts should be expressed in the same terms still, were the case still to open.

2. It was not the expression of these doubts, however well founded they might appear to him, which induced Professor Geikie to suppress this "stock instance" in the last edition of his work; it was the corroboration or substantiation of them by the Committee of the British Association failing to find the clay in the position indicated by all the accounts of it, or in the neighbourhood. Dr. Geikie then justly suppressed it, as unsupported by evidence; the only fault that can be found with him being that he did not state any reason for doing so.

3. Though in one sense the result of the Committee's investigation was *negative*, in so far that the clay was not found, in another it was quite *positive*: the clay was not where it was reported to be. It was said to be in the excavation for a certain well, 14 ft. from the surface, as a bed 19 ft. long by 5 ft. broad, and 2 ft. thick in the centre. The Report of the Committee showed that no such bed of clay could have escaped their search, and that in other respects the statements so long repeated did not tally with the facts (see British Association Reports, 1894). It was evident that "some one had blundered," or had been misled. Why this result should be called "futile" because something else—a boulder-clay at the same or a greater elevation—has been discovered elsewhere, I cannot imagine. Every case must be decided on its own evidence. Chapelhall has collapsed. The value of the Ayrshire sections as proofs of submergence has yet to be determined. My own opinion, frankly, is that it is *nil*; but I keep my mind open till the evidence be more fully wrought out, and meantime deprecate hasty and sweeping statements on the subject.

4. In another part of his paper Mr. Mellard Reade speaks of "a great glacier proceeding from the Atlantic, crossing Kintyre and the Firth of Clyde, and working 25 miles inland" into Ayrshire, as if that were the idea involved in the theory of those

who do not accept submergence. We are sorry our friend should have indulged in such a fantastic supposition. Is not the bed of the Firth of Clyde itself large enough to supply any marine remains that may be in question? Why go out to the Atlantic for them? The truth is, the whole evidence goes to show that such was the congested and over-brimming condition of the Firth of Clyde as one of the main outlets for the land-ice of the country—the ice of the West Highland, Ayrshire, and Galloway mountains, augmented by that of Arran in the Firth itself—that a large section of the frozen stream was deflected *westward across Kintyre* (exactly in the opposite direction figured by Mr. Reade), and so *out* to the Atlantic in that direction (see Brit. Assoc. Report, Kintyre Shelly Clays, 1896). Finally, when the ice in the Firth of Clyde was of such dimensions that it passed straight on over Bute, the Cumbraes, and Ailsa Crag, where do we suppose its outer edge lay in Ayrshire, or along the Ayrshire coast? Can we fix a nearer point for it than along the flanks of the hills which divide Ayrshire from Renfrewshire and Lanarkshire, where fragments of West Highland rocks are numerous, and these patches of high-level shelly boulder-clay are chiefly found?

V.—THE OLDEST *SIPHONOTRETA*.

By G. F. MATTHEW, D.Sc., F.R.S.C.

(Read before the Natural History Society of New Brunswick, January 5, 1897.)

THE ancient Brachiopodous genus *Siphonotreta* is well known by its species occurring in the Ordovician and Silurian strata of Russia and Great Britain, and its peculiar pedicle opening has been the subject of remark. The author is not aware that this genus has hitherto been reported from any Cambrian terrain, and, therefore, the greatest interest will attach to a form recently found in the lower beds of the St. John Group, which is nearer to *Siphonotreta* than to any other known genus.

The new form is remarkable, so far as its pedicle passage is concerned, in combining the two genera *Siphonotreta* and *Schizambon*; for in its early stages it had the dorsal furrow of the latter genus, but afterwards it developed the tubular passage seen in the former.

This shell is older than any *Paradoxides*, being of the *Protolenus* Fauna,[1] and is found in strata that nearly correspond in age to the beds which at another locality carry the related genus *Trematobolus*. But while the new form abandoned the Schizambonal opening for its pedicle, and adopted a contracted canal for the passage of this organ similar to that of *Siphonotreta*, *Trematobolus* maintained the open fissure (or hole) through life.

Young individuals of the new form of the size of *Schizambon typicalis*, Walcott, are actual examples of the genus *Schizambon*. The history of the growth of the species from the larval forms to maturity is shown by exfoliated shells, in which the siphon stands out, while the adjoining shell-layers are weathered away. The shell of this species was thin during the Schizambonal stage, but thickened rapidly by the accretion of layers within the shell during the Siphonotretal stage. As, however, the parts of these layers around the tube were not perfectly calcified, that organ in exfoliated shells stands out and remains as a projecting tube, after the layers of shell, as above remarked, are weathered away.

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[1] Trans. New York Acad. Sci., vol. xiv, pp. 101–153.

In an exfoliated shell, therefore, we have a siphon projecting from what seems to be the inner side of the shell, and simulating the figures given of the interior of the ventral valve of *Siphonotreta unguiculata*, Eichwald.[1] And the resemblance to that species in other respects is significant, for, in the first place, the passage for the pedicle in the new form diminishes in size from that which it had at the close of the Schizambonal stage, until maturity; and it will be noted that in the species of *Siphonotreta* named above, it is said that the internal tube diminishes in size as it passes inward.[2]

It is also stated that in *Siphonotreta unguiculata* the muscle-marks are very near the internal opening of the tube. This is not noticeably the case with the new form when the interior of the shell is completely preserved; but in exfoliated examples where the siphonal tube is exposed, the muscle-markings on the shell-layers remaining, being those of the early Siphonotretal condition, are much nearer the siphon, and so are like those accredited to the species above named.

The new form has no exsert siphon showing on the inner surface of the shell, and it will easily be seen that such a projecting tube would involve anatomical conditions different from those of most of the early Neotrematous Brachiopoda. It would appear that a siphon projecting inside the shell is not an invariable characteristic of *Siphonotreta*, for Davidson figures *S. unguiculata* with a scarcely projecting siphon,[3] and De Verneuil shows the inside of an umbo of *S. verrucosa*, De V., in which the opening for the pedicle lies in a little saucer-shaped hollow, as in our species.[4]

In some species referred to *Siphonotreta*, the pedicle passage opens outward just behind the beak; in others a channel extends along the back of the shell for some distance, and then a hole gives passage to the interior of the shell, there being no siphon or tube. These latter have been divided off by Walcott as the genus *Schizambon*. Since, however, the St. John species agrees exactly neither with this section nor the other, but in its pedicle passage combines the characters of both, it is necessary to establish for it a separate place. Linking together as it does the genera of De Verneuil and Walcott, it would seem proper to regard both *Schizambon* and the new form as subgenera of *Siphonotreta*, and with this view the author would propose for the new form the name PROTOSIPHON, for which the above remarks will give the essential characters.

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[1] See "Manual of the Mollusca," S. P. Woodward, London, 1875, p. 390, fig. 201.

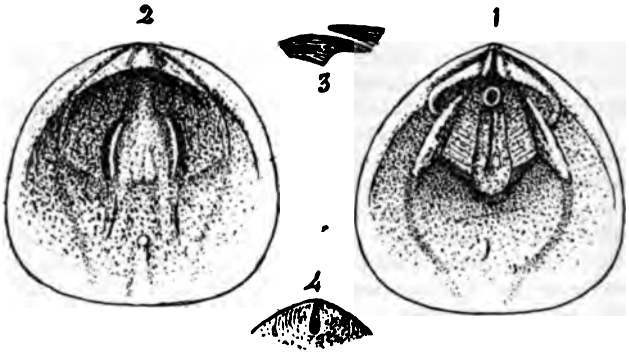
[2] Hall and Clarke, "Genera of Palæozoic Brachiopoda," Albany, 1892, p. 110.

[3] GEOL. MAG., London, 1877, Pl. II, Figs. 9, 11. See also Hall and Clarke, "Genera of Palæozoic Brachiopoda," pl. iv, fig. 25.

[4] "Russia and the Ural Mountains," Paris, 1845, vol. ii, pl. i, fig. 14d.

PROTOSIPHON, n. subgen.

PROTOSIPHON KEMPANUM, n.sp.[1]



Protosiphon Kempanum.—1. Interior of the ventral valve, showing scars of central and lateral muscles, opening of the siphon, vascular trunks, etc. 2. Interior of the dorsal valve, showing position of the central and lateral muscles, median ridge, vascular trunks, etc. 3. Section of the beak of the ventral valve, showing the passage for the pedicle. 4. Umbo of the ventral valve viewed from above, showing the Schizambonal furrow.—All the figures are magnified $\frac{8}{1}$, except No. 3, which is enlarged $\frac{4}{1}$.—N.B. The large figures are somewhat idealized, as some features (e.g. the vascular trunks) are supplied from examples other than the two which formed the basis of these drawings.

Shell substance calcareo-corneous. Outline of the dorsal valve somewhat oblately orbicular; outline of the ventral valve similar, but with an obtusely pointed beak. Both valves moderately convex, and marked at the hinge area by transverse ridges of growth. The ventral valve has a depressed channel on the back, beginning at the beak and ending forward in a tube buried in the substance of the shell, and terminating inwardly in the visceral cavity by a minute opening.

The dorsal valve does not differ much from the ventral, except in the absence of a projecting beak, and in being more tumid in the posterior half. Both valves have a broad, shallow sinus towards the front, and so are there straighter than in other parts of their circumference.

The edges of both valves are flattened on the underside, and thickened at the cardinal line, where they are traversed by arched ridges and furrows, which may serve the purpose of articulation. A depression similar to a pedicle groove traverses the cardinal area of the ventral valve on the axial line; and a low tubercle holds a similar position on the dorsal valve.

Sculpture.—The surface of the shell is marked by fine lines concentric to the umbo, and at intervals by stronger growth-lines

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[1] Dedicated to Dr. J. F. Kemp, Professor of Geology at Columbia College University, New York, well known for his work on the Archæan and Cambrian Geology of the State of New York.

Interrupted rows of tubercles appear in certain places along these lines of growth.

Size.—The largest dorsal observed was 19 mm. long and 20 mm. wide. A ventral valve of corresponding size would be 1 mm. longer. Height of each valve about 5 mm.

Horizon and Locality.—In the olive-grey sandstones of Division 1*b* of the St. John Group at Long Island in Kennebecasis Bay, King's County, N. B. Canada. The exact horizon in Band *b* is uncertain: there are about fifty feet in thickness of these sandstones exposed, and they have the aspect of Assises 2 to 4; being from the upper part of the sandstones the species is probably from Assise 3 or Assise 4. These shells are found sparsely distributed in sporadic, lenticular layers, having the valves promiscuously packed within each other, as though after death they had been somewhat rolled on a beach, or in a shallow sea.

Further particulars of this species will be given in an article in preparation for the Royal Society of Canada.

ST. JOHN, N. B. CANADA.

REVIEWS.

I.—DR. CROLL'S LIFE AND WORK. By JAMES CAMPBELL IRONS, M.A. pp. 553, including Index and two Portraits. (E. Stanford, 1896. Price 12*s*.)

SIX years have elapsed since the death of Dr. Croll, and we are now presented with a Memoir of his Life and Work from the pen of his Edinburgh friend, Mr. J. C. Irons, assisted in some degree by his brother, the Rev. David E. Irons, of Glasgow. We quite agree with the author that the life of such a man, "recording the triumph over his early struggles, his scientific researches, which secured him a worldwide reputation as an original thinker, and his earnest belief in the Christian faith," should prove interesting. There is something fascinating in Croll's biography. His was an eminently Scottish type of character, and it may be safely asserted that no other country than North Britain could have produced such a marked individuality.

His autobiographical sketch (pp. 9–41), constituting a sort of introduction to the present volume, should be read carefully in order to understand the man. We thus realize, from the perusal of a few clearly-written pages, his struggles with poverty and ill-health, his thirst for knowledge, his natural inclination towards metaphysics, his ultimate absorption in physical speculations, his fortunate appointment as doorkeeper at the Andersonian Museum in Glasgow, and, lastly, his acceptance of employment on the Geological Survey of Scotland. It is only right to add that he tells us of his general indifference, in the outset of his career, for sciences involving so much detail as geology and chemistry. As regards the former, he observes (p. 14) that it is the only science on which (with the exception of glacial phenomena) he never spent a single day's earnest study.

It is not our purpose to offer any criticisms in the GEOLOGICAL MAGAZINE on the volume by Mr. Campbell Irons now before us, although a short synopsis of its contents may not be altogether out of place.

The early days of the Perthshire youth are duly recorded; and from this we pass to notices of his literary and early scientific work. As regards the latter, our author observes (p. 97) that "for many years he [Croll] devoted his attention chiefly to the great problems of theoretic geology, and in 1864 he began the brilliant series of solutions which make his name illustrious in the history of this science." An account of the early physical papers, 1861–4, is given, and we learn that, about the latter date, Dr. Croll received the congratulations of the late Sir Andrew Ramsay on his work. He was now fairly launched in his career of scientific speculation, and, as a consequence, entered into correspondence with Ramsay, Lyell, Herschel, Hooker, Charles Darwin, and other eminent men, both geologists and physicists. A very considerable portion of the volume is devoted to this correspondence in connection with the several subjects taken up by Dr. Croll, all of which bore more or less on the questions discussed in "Climate and Time," first published in 1875. In the following year he was elected a Fellow of the Royal Society.

This intermingling of personal history with scientific correspondence is continued down to the period when Dr. Croll found it nécessary, in 1881, to resign his appointment on the Geological Survey of Scotland owing to ill-health, after having served for thirteen years. The scientific correspondence is still maintained, and the letters he received with reference to "Climate and Time," "Climate and Cosmology," etc., are often very suggestive. Amongst other things Dr. Croll tried his hand at "Stellar Evolution," a pursuit which involved him in correspondence with Winchell, G. H. Darwin, Alfred R. Wallace, and other distinguished scientists. In 1889 he received a letter of thanks from Dr. Nansen, to whom he had sent copies of some of his works.

The concluding chapters relate to the "Closing days" of Dr. Croll's career, when he returned to speculations more or less metaphysical. The "Philosophical Basis of Evolution" was his last work, and this he was just able to see in print before he died. Mr. Irons also reproduces obituary notices—by Lord Kelvin as President of the Royal Society, by a writer in *Nature*, and by Mr. J. Horne, of the Geological Survey of Scotland, all of which do justice to Dr. Croll's character and attainments.

A considerable portion of Croll's work made its first appearance in the *Philosophical Magazine* and in the *Reader*, but he also contributed several articles and letters to the GEOLOGICAL MAGAZINE, more especially in the years immediately preceding the publication of "Climate and Time." The substance of these articles was for the most part embodied in that work, more especially one "On the Path of the Ice-sheet in North-Western Europe and its Relations to the Boulder-clay of Caithness." In the GEOLOGICAL MAGAZINE for September, 1878, he wrote an article criticizing "Cataclysmic Theories of Geological Climate," and there have been a few short communications of a subsequent date.

Very different estimates have been formed from time to time of the value of Croll's speculations, though none can doubt that they offer problems of a deeply interesting nature. We may almost regard "Climate and Time" as a poem; though its author was perhaps somewhat too controversial in his nature to be regarded as a genuine *vates.* It is not for us, as geologists, to question the accuracy of the calculations whereby the eccentricity of the Earth's orbit has been estimated throughout three million years of past time and one million years of future time. Leverrier, it seems, was content to give a table of the eccentricity for 100,000 years before and after A.D. 1800. This was thought sufficient for ordinary astronomical purposes, but is clearly too limited for geological epochs. The most curious feature in this connection is the statement by Croll's biographer (p. 491) that "the keenness and directness of his marvellous logical faculty is by no means least clearly demonstrated in his marvellous calculations of millions of years and intricate mathematical problems, which, as he knew little of mathematics, he worked out by a process of figure-logic entirely his own." We also learn incidentally from a statement made by Lord Kelvin (p. 500) that Croll was not at all times very sound in arithmetic. Nevertheless, the same authority observes that his "Essay on the Physical Cause of the Changes of Climate during the Glacial Epoch" deservedly gained the careful consideration both of geologists and of astronomers.

Although some may be disposed to question the value of Croll's calculations, there can be little doubt that many of his arguments on terrestrial physics carry considerable weight with them. There is a certain fascination about his theory of the alternate glaciation of the hemispheres; whilst it is indisputable that at the present time, notwithstanding the low value of the eccentricity, the hemisphere whose winter is in aphelion is much the colder, as required by his hypothesis. How far Lyell's explanation of this fact is to be relied upon it is difficult to say; but one apparent cause, as pointed out by Croll, may be sought in the northerly deflection of the equatorial currents, whereby a portion of the warmth which should belong to the southern hemisphere is transferred to the northern. But what is the agency which brings this about? According to Croll, it is the excess of southern cold producing a preponderance of the south-east trade-winds. We are thus forced to fall back on the *primary* cause of this excess of cold, which Croll no doubt would attribute to the fact of the southern winter occurring in aphelion. Other physicists there are who contest this conclusion. A better acquaintance with the Antarctic regions than we at present possess might be of service at this stage of the inquiry.

Whether right or wrong, the Astronomical Theory of Geological Climate, which found in Croll its most original advocate, has met with no small degree of acceptance in the world of science. Thus, under the article "Geology" in the *Encyclopædia Britannica*, Croll contributed an outline of the "Secular Theory of the Change of Geological Climate"; whilst a full abstract of his views on Climate in its Geological relations, drawn up by himself, was admitted into Sir Archibald Geikie's "Textbook of Geology" (1882, p. 23 et seq.). More recently somewhat similar views have been expressed by Sir Robert Ball in his "Cause of an Ice Age," which appeared in 1891, and has since been published in the "Modern Science" Series, thus indicating by implication the general acceptance of the theory, now no longer regarded as a mere hypothesis.

Nevertheless, from time to time, critics have arisen who ventured, in a greater or less degree, to contest the methods by which these conclusions have been reached. It will suffice to instance two from our own pages. The Rev. E. Hill, in an article on "Eccentricity and Glacial Epochs" (GEOLOGICAL MAGAZINE, February, 1880), prefaces his criticisms by the admission that "Climate and Time" was perhaps the most important geological work that had recently appeared; "certainly," he says, "the most valuable and original that refers to Glacial Geology. It teems with novel and instructive ideas." Then comes the criticism, summed up as follows:—"We have thus gone through Dr. Croll's four causes, or rather modes of action, whereby high eccentricity might, as he maintains, produce a Glacial period. The first is non-existent. The second may possibly have an effect. The third at best cannot work at all, and almost certainly works in the wrong direction. The fourth [deflection of ocean currents owing to intenser trade-winds] might work if set agoing, but has no power of starting itself?" Mr. Hill's verdict, therefore, was one of "Not Proven," though he considered that Croll had attacked the problem in a right manner; and he seemed inclined to believe, with Croll, that variations in eccentricity did bring about the Glacial period.

More recently the Astronomical Theory of the Ice Age, as enunciated by Croll, and subsequently (1891) by Sir Robert Ball, has been criticized by Mr. E. P. Culverwell, Fellow of Trinity College, Dublin, in the GEOLOGICAL MAGAZINE (January and February, 1895). This author considered himself justified in stating "that a careful examination of the problem will show that the theory is but a vague speculation; clothed, indeed, with a delusive semblance of severe numerical accuracy, but having no foundation in physical fact, and built up of parts which do not dovetail one into the other." It is for mathematicians and physicists to decide between these contending authorities. But we may, at least, call attention to Seebohm's description of the advent of summer in Siberia, as quoted by Mr. Culverwell; who complains that Croll's illustrations of the effect of summer heat are all selected from regions where the sun-heat has to contend, not only with the ice or snow actually on the ground, but also with the cold drift-currents bearing great masses of ice and snow from the Polar regions.

Apart from all considerations involving abstruse mathematical demonstration, there is one important section of Croll's speculations which must commend itself to those who are desirous of investigating the subject of Climates, past and present. He insisted upon the importance of the warm-water apparatus of the globe in modifying these. We may even believe with him that the "real and effective cause of the disappearance of the ice [of the Glacial epoch] was the enormous transference of heat to temperate and polar regions by means of equatorial currents" (GEOLOGICAL MAGAZINE, 1879, p. 480). True, it is difficult to understand in view of his theory that the colder hemisphere forces the equatorial currents away from itself, how this could be, unless some other and more powerful cause operated to counteract the above-mentioned tendency. This, however, merely refers to causes directing the equatorial currents, and does not affect the general question of their influence.

The general oceanic circulation is, of course, modified by latitude and certain local causes, and this is especially noticeable in the North Atlantic; where the steady set of warm surface water towards the north-east, partly initiated by the Florida current, helps to produce such a remarkable contrast between the climate of western Europe and that of corresponding latitudes in eastern America. This difference is evidently one of some antiquity, since the causes whice produce it now were evidently in operation in the Glacial epoch. For the glaciation in eastern America, as was thoroughly realized by Croll, extended some ten degrees further south than it did in western Europe. This fact should be borne in mind by persons who are desirous of attributing the cold of the Glacial epoch to interference with the Gulf Stream, since some of the effects for which that agency is held accountable were certainly produced during the period of Pleistocene glaciation.

Lastly, we must consider Croll as a geologist, or rather as a glacialist, for he expressly repudiates any knowledge of geology otherwise than in connection with Boulder-clay. In this department he may be said to have done some really practical work by helping to demonstrate the occurrence of important physical features, such as pre-Glacial river-channels, etc. Indeed, his acquaintance with Boulder-clay areas in the Scottish Midlands seems to have been one of his strong points, and he was able to draw important inferences from the knowledge thus obtained.

Although much that belongs to the history of the Glacial epoch remains as mere hypothesis even to the present day, we owe to the school of which Croll was an eminent member the recognition of the fact that the phenomena of the Boulder-clay and its accessories are in the main due to the action of land-ice. After Jamieson's brilliant explanation of the origin of the parallel roads of Glenroy, the land-ice, or glacier theory, has passed from the region of hypothesis to that of demonstration, and should form the basis of all reasoning on the subject. It follows, therefore, that the valleys of Scotland and the north of England must at one time have been gorged with ice, and thus many of Croll's postulates are undoubtedly true. But his was a vivid imagination, and the *perfervidum ingenium* of his race transported him, possibly beyond the bounds of probability, in the tremendous expansion which he gave to the glaciation of these islands generally. Moreover, there is reason for supposing that, even subsequently to the publication of "Climate and Time," he was a believer in a general Arctic ice-cap (see GEOLOGICAL MAGAZINE, 1878, p. 396); whereas it is pretty clear, from the experiences of Nordenskiöld and other eminent scientific travellers, that glaciation, as developed in the northern hemisphere, is a local phenomenon dependent on the existence of mountain ranges, or at least of elevated tracts of land. In the Arctic Ocean itself such an island as Kolguev, for instance, has received its glacial débris from the high lands to the southwards, and not in any sense from the direction of the North Pole.

In other respects also Croll's geological ideas were of an eminently speculative character. He marshals an imposing array of figures, as usual, to account for the Great Submergence, which many students of glacial phenomena in these islands regard with considerable doubt, beyond the moderate depression which is indicated by the raised shell-beaches. Indeed, the more advanced glacialists of the present day rather affect to look down upon a "submerger"; whilst some express strong doubts as to the occurrence of Interglacial periods.

But the most awkward circumstance in the geological aspect of Croll's astronomical theory remains yet to be stated. If that theory is sound, there must have been, throughout the Earth's history, a constant recurrence of Glacial epochs. Admitting that considerable climatic changes have been effected, from time to time, by the deflection of ocean currents and the uprise of mountain ranges, is there any evidence, geologically speaking, of the regular recurrence of Glacial periods, as required by the astronomical hypothesis? The geological record is so meagre on this score that Croll felt it necessary to dwell with considerable emphasis on the "misconceptions regarding the evidence of former Glacial periods," arguing that the traces of glaciation are principally to be found on land-surfaces, and that the transference of a land-surface into a sea-bottom would probably obliterate every trace of glaciation. We know that Croll believed in two great epochs of glaciation in Tertiary times, the one in the Eocene and the other in the Miocene period. These he supposed to correspond to certain periods of excessive excentricity, as indicated in his famous diagram. The evidence is confined to regions within the range of Alpine influences, and is perhaps of about as much value in proving the existence of a "Glacial epoch" as the occurrence of a few granite boulders in the Chalk.

The most certain evidences of glaciation previous to the Pleistocene Ice Age are to be found in the southern hemisphere, although even these proofs do not of necessity imply a "Glacial epoch" e splendid photographs of the famous glacial conglomerate of ild Duck Creek, brought out by Mr. Dunn in 1892, are probably niliar to some of our readers. The striated bed-rock, believed to of Silurian age, is most strikingly shown. The subject has been cently brought before the Geological Society by Professor dgeworth David (February, 1896), who called attention to the Evidences of Glacial Action in Australia in Permo-Carboniferous imes." It is of course obvious that, if a mountain range tained a certain elevation, it must have been glaciated; but is was more than a mere local phenomenon, and undoubtedly ggests questions of immense interest in relation to the history f the Earth's crust. Quite recently Mr. Strahan has brought to the otice of the Geological Society of London what he regards as lacial phenomena of Palæozoic age in the Varanger Fjord.

Conceding its full weight to the evidence of some glaciation in ustralia, and possibly in South Africa, and even India, in Permo-arboniferous times, it must be admitted that the geological record s by no means conclusive as to the frequent occurrence of Glacial pochs. On the whole it may be said that, whilst cosmogonists and peculative physicists are perfectly ready to accept evidences of laciation, and even of several Glacial epochs, throughout the ages, yet geologists, with few exceptions, have failed to draw those inferences which the astronomical hypothesis requires.

It may interest those who are intending to purchase a copy of this work, that the profits of the sale of the book are to be handed to the widow of Dr. Croll, who has been left in somewhat straitened circumstances.

II.—PREHISTORIC MAN AND BEAST. By the Rev. H. N. HUTCHINSON, B.A., F.G.S. With Illustrations. 8vo; pp. xxiii, 298. (London, 1896: Smith, Elder & Co. Price 10*s*. 6*d*.)

THE author, an old Rugbeian, who learned his first lessons in Geology under that able and enthusiastic teacher the Ven. J. M. Wilson (now Archdeacon of Manchester), makes his third public appearance in the volume before us. His previous works, "Extinct Monsters" and "Creatures of Other Days," have made his name known as a successful popular writer, more especially as they inspired the clever "Prehistoric Peeps" which were contributed to *Punch* by Mr. E. T. Reed. Unfortunately, this artist in his later sketches has allowed his imagination to run riot with the subject, and to mar the scientific humour of his work.

"Prehistoric Man and Beast" is a book which aims to give, in a simple style, some of the most interesting results arrived at of late years on the antiquity of Man and of the animals associated with him. Such an undertaking is no light one. Above all, a sound judgment must be combined with the knowledge acquired by extensive reading, and with clearness and facility of expression. Only with respect to the first of these qualifications do we find occasional fault with the author, though we can well believe that innocence rather than intention has in certain instances warped his judgment. This is not surprising when we read in the Preface by Sir Henry Howorth: "My only hesitation in speaking of the book in suitable terms is the exaggerated language which he has been good enough to use about some of my own scattered and desultory gleanings in this field." Nor is it surprising when we read in the author's Preface: "Sir Henry H. Howorth has taken an interest in this work from the beginning, and most kindly read all the proofs, making at the same time valuable notes and comments, which the writer was not slow to use. He has also written a far too flattering Preface, which, coming from so learned an author and so kind a friend, deserves the writer's warmest thanks." After this we are quite prepared for an exposition with approval of some of Sir Henry's peculiar views: and in this respect we are not disappointed.

In his Introduction the author remarks that he makes no attempt to deal with modern speculations regarding the origin of Man from a lower type: "Suffice it to say that he bears in his body the signs of his lowly origin; and that nearly all thinking people of the present day fail to see anything in such a belief contrary to true theology, or to consider that there is anything degrading in the idea." This view may, at any rate, be commended for its boldness.

That the germs of many modern views may be discerned in the writings of the ancients, is to a certain extent true enough; and it is interesting to be reminded that in the days of Job ("if ever such a person lived"), there were observers of geological phenomena. Another writer, indeed, has remarked that to Job probably we owe the hint of the Atlantic Cable, for he was asked—"Canst thou send lightnings, that they may go, and say unto thee, Here we are?" Be this as it may, a reference to the opinion of the wise men of old, whether historians, naturalists, or philosophers, is instructive, and no one need be surprised to be told that "the account of the Creation in the opening chapters of Genesis *implies* evolution."

Starting from the evolutionist's standpoint, the author devotes his first chapter to a consideration of "Our Early Ancestors." He gives an account of the discoveries of Palæolithic implements, and of supposed remains of Palæolithic Man, treating the subject in a very fair and judicious spirit. He hesitates to accept the higher antiquity assigned to the plateau implements of Kent, and he is quite disposed to accept the human remains found at Galley Hill as belonging to a man of the River-drift period. With regard to the position of the implements found at Caddington and elsewhere, it should be remarked that the "contorted drift" there noticed is simply a disturbed surface of the brickearth or gravel, such as is often seen in the Thames Valley deposits. It has no connection with the Contorted Drift of the Cromer coast, nor has it been shown to have anything to do with the Chalky Boulder-clay. The author thinks "there can be little doubt of the former presence of floating ice here"; but soil-movements connected with freezing and thawing would have been quite adequate to produce the phenomena.

Chapter II contains an excellent account of "Ancient Cave-dwellers," and the author very properly remarks that "The whole question of the true or exact age of the older deposits of British and other caves is still more or less *sub judice*." At the same time he says "it is generally believed that Palæolithic man, and the extinct animals with which he is associated, lived here [in the north] when all our valleys, as far south as the Thames, were occupied by glaciers, and the higher grounds by snowfields." This is far from the case. The Boulder-clay, which is considered newer than some of the Cave-deposits in the north of England, is itself almost certainly newer than the Chalky Boulder-clay, which, occurring as far south as the Thames Valley, has been found at one place beneath the Thames Valley-gravel. In the previous chapter (p. 22) the author is inclined to take the view held by Prestwich, that the old river-gravels with Palæolithic implements were formed during the latest phase of the Glacial period; and recent evidence supports the view that the implements are newer than the Chalky Boulder-clay. Chapter III is devoted to "The Reindeer Hunters"; and then in Chapter IV we have the least satisfactory portion of the book, entitled "The Myth of the Great Ice Sheet, and Theories of the Flood." In this chapter the author's usually calm and considerate treatment of facts and opinions seems to have deserted him. He has evidently been upset by "The Glacial Nightmare and the Flood." Curiously enough he speaks in his Preface "of the clever special pleading of Prof. James Geikie and Sir Robert Ball," and now he follows the lead of "that valiant but most courteous fighter," Sir Henry Howorth! The idea of a great Polar ice-cap has been repugnant to some who are not simply critics, but observers of Glacial phenomena; yet the extent of ice in the Arctic regions now can hardly be considered as a test of that which may have been present during the Glacial period. The magnitude that has sometimes been assigned to old ice-sheets may be curtailed, but the facts of the extensive glaciation remain. It is well to remember that every view, when new, is apt to be somewhat exaggerated by authors and their disciples. Opinions differ with regard to the number and importance of milder inter-Glacial episodes, and also with regard to the actual extent of the maximum land-glaciation. If, however, in our interpretation of these Pleistocene phenomena, we had to choose between the most extreme of Glacial and the mildest of Diluvial hypotheses, we should have no hesitation in saying that the former was far more in accord with facts.

Happily our author is not led away into advocating any universal Deluge. He readily admits the evidence of glaciation, though not, apparently, to the extent that is generally taught and generally accepted. It is, however, not entirely easy to reconcile all his statements. He remarks that "land-ice in the form of glaciers is generally believed to have had more to do with forming the drift deposits than anything else." He admits "a modest local or British ice-sheet formed by confluent glaciers," and he gives an excellent description of

Boulder-clay. He fails to find any satisfactory explanation of the occurrence of Scandinavian boulders in our drift, and he tells us that Sir Henry Howorth has abandoned the notion that such stones were brought as ballast by the Vikings. Yet he uses most inconsiderate and exaggerated language when referring to the work and views of men like Agassiz, Ramsay, Croll, and James Geikie, when a calm and dispassionate view of vexed questions would have been far more appropriate. So much of what he says is good, and he appears so animated with the desire to present the truth, that his tirade is deplorable. Even the term "Great Ice Age" seems to have aroused the indignation of our otherwise temperate author; but the reader must pass by the uncomplimentary exclamations and pay attention to the facts.

With regard to the comparative nearness in time of the Glacial period, the author would date the ending of it to not more than 15,000 to 25,000 years—these are the rough limits he would assign to the antiquity of Man, and he says "the Palæolithic hunters were *certainly* here during the Glacial period." He thinks "It is ridiculous to suppose that the glacial striations in Wales or Scotland, to say nothing of moraines, etc., could have survived for so long a period" as Croll suggested—80,000 years. No doubt many striations have been effaced; others are preserved, and may be long preserved, beneath mantles of Boulder-clay. What, then, is the worth of such an argument? The author admits that civilized man appears to have lived in Egypt about 10,000 years ago. We must, therefore, be patient in awaiting further evidences before speaking with confidence on this vexed subject of Man's antiquity.

There is a curious slip on p. 144, where the author says: "Again, there are the high-level gravels, containing Palæolithic implements such as those of the Thames, to be seen at Hampstead Heath": we have never heard of any such discovery. And on p. 154, Dr. *Keith*, instead of Dr. *Hugh* Falconer, is mentioned. Such slips are, however, rare, and we may speak confidently of the careful way in which the author has given his facts and references.

The second part of his book deals with Men of the later Stone Age and Bronze Age; with lake-dwellings, kitchen-middens, barrows; with the science of fairy-tales and folklore, and with various megalithic monuments. The subject is treated in a full and pleasant style, and it will be read with interest and profit. The ten illustrations by Mr. Cecil Aldin are of a more sober type than those (previously alluded to in *Punch*) by Mr. E. T. Reed, and they are doubtless more true to nature.

III.—GEOLOGICAL SURVEY OF CANADA.—G. M. DAWSON, C.M.G., F.R.S., Director. Annual Report (New Series): Vol. VII, 1894. (Ottawa: S. E. Dawson, 1896.)

HEREIN is described the great field of work in which the Canadian geological corps carried on their operations during the season of 1894, under their new Director, Dr. G. M. Dawson.

"The surveys," writes the Director in his summary report (pp. 1 A to 124 A), "consist of—(1) Reconnaissance surveys and explorations, covering in a general way large tracts of country; and (2) the systematic mapping and description in detail of less extensive areas. The first inevitably precedes the second class of work, and for many years it must, in the nature of things, remain the only method possible of dealing with the vast regions of Canada which lie beyond the boundaries of connected settlement." The distribution of the field parties was as follows: British Columbia, 2; North-West Territories (boring operations), 1; Keewatin District, 1; Ontario, 3; Quebec, 1; Labrador Peninsula, 1; New Brunswick, 1; Nova Scotia, 2: total, 12.

Experimental borings at Athabasca Landing, on the river of that name, favour the belief in the existence of a great petroleum-bearing region in the north-west; and it is suggested that if the oil could be supplied at a low price, it would be employed as a liquid fuel for railways in the North-West Territories and British Columbia. A large foreign demand might also be met from this region, such as that now supplied by the United States from their own resources to Japan and China.

The work done in British Columbia by Dr. Dawson and his two assistants, Messrs. McEvoy and McConnell, forms the subject of an extensive report on the area of the Kamloops map-sheet (pp. 1 B to 427 B). An interesting feature in this exploration was the examination of some important deposits of economic minerals, consisting of cinnabar, copper-ore (not very productive), and magnetic iron-ore. An inspection was also made of the property of the Van Winkle Hydraulic Mining Company, on the west bank of the Fraser River, about two miles above Lytton. The working of auriferous gravels in the higher terraces or "benches" of the Fraser, rising from the river in successive steps, is here being carried out by the hydraulic method. All the gravels here exposed are believed to be later Glacial or post-Glacial in age. No Boulder-clay is seen, nor is any true bed-rock reached. It is comparatively poor in gold. Hydraulic mining for gold is also carried on in the Cariboo district with apparently encouraging prospects. The importance of glacial action in relation to this alluvial gold-mining is insisted on, the superficial filling up of the valleys in which the gold is worked having resulted chiefly from the deposits and effects of the ice of the Glacial period. Dr. Dawson observes that "a much more general interest is being awakened in mining throughout the province, and it may be safely affirmed that British Columbia has now fairly entered on a period of rapid and thorough development of its mineral resources."

Under the heading of "General Geology" an outline of the main features of the formations met with in the area of the Kamloops sheet is given. These rocks consist of the following:—

			Feet.	
Early Pliocene?	... ...	Conglomerates.		
Later Miocene.	... ...	Volcanic rocks, largely basalt	3,100	
	Tranquille beds.	Bedded tuffs	1,000	
Earlier Miocene.	... ...	Volcanic rocks, largely porphyrites	5,300	9,
Oligocene.	Coldwater Group.	Conglomerates and sandstones		5,
Earlier Cretaceous.	Queen Charlotte Islands formation (chiefly).	Sandstones, conglomerates, and argillites		7,
Triassic (and Lower Jurassic).	Nicola formation.	Chiefly volcanic; some limestones and argillites 7,500 to		13,
Upper Palæozoic (chiefly Carboniferous).	Câche Creek formation.	IN WESTERN DISTRICT. *Upper part.*—Marble-cañon limestone, with some volcanic rocks, argillites, and quartzites	3,000	
		Lower part.—Argillites, quartzites, and volcanic rocks, with some limestone	6,500	9,
		IN EASTERN DISTRICT. *Campbell Creek beds?*—Argillites and amphibolites ... ... about	5,000	
		Argillites and grauwackes, limestones and volcanic rocks	7,500	12,
Lower Palæozoic (chiefly Cambrian).	Adams Lake Series.	Chiefly volcanic rocks, with some arkose conglomerate. Thickness actually observed in Kamloops sheet, 9,500 feet. Total thickness in adjacent Adams Lake section	17,100	
	Nisconlith Series.	Chiefly dark argillites. Thickness actually observed in Kamloops sheet, 2,000 ft. Total thickness in Selkirk Mountains section ...	15,000	3
GENERAL SECTION OF KAMLOOPS REGION				89

It is regarded as well within the limits of probability to esti the volcanic materials of the interior plateau region of Bri Columbia at about 20,000 feet in total thickness. The width of belt of volcanic rocks may be assumed to be about 100 miles. vast extravasation must have been accompanied by enormous sidences, which probably corresponded generally with the pre position of the coast ranges. There were, however, recur periods of elevation which resulted in the production, at more *one period,* of a chain of mountains along this line, which more than once carried away by denudation, until at the present day we find the existing mountains low in comparison with some of those of the further interior, but consisting for the most part of granitic rocks of deep-seated origin, with but scanty remnants of the older members of the Palæozoic series resting upon their flanks or remaining as infolds in their mass. Very often, and over large areas along the littoral of these ranges, the beds which rest directly upon the granites are of Triassic age; but from this it is not to be argued that the older formations have never existed there, for these may only have passed beyond recognition by entering as component parts into the subjacent granitic magma.

Under "Descriptive Geology" (pp. 79 B to 308 B) local details are entered into, and the data relied upon in laying down the geological lines discussed; these supplement the broad indications afforded by the map. Appendices follow: (1) upon the petrographical characters of some rocks from the area of the Kamloops map-sheet, by W. F. Ferrier; (2) Shuswap names of places, by Dr. G. M. Dawson; (3) upper and lower limits of growth of some trees and other plants as climatic indices; (4) comparative observations of temperature at different altitudes in or near the region embraced by the Kamloops sheet, southern interior of British Columbia, during parts of the years 1888, 1889, and 1890.

Mr. R. G. McConnell (Report, pp. 1 C to 40 C) was engaged during the earlier months of the year in working up the results of his exploration of the previous summer in the Finlay River and Omenica country, of northern British Columbia. The oldest rocks in the district are of Archæan age, and belong to the Shuswap series of Dr. Dawson. They consist of a series of well-foliated mica-gneisses, probably derived to a large extent from sheared eruptives, lustrous mica-schists, hornblende- and actinolite-schists, quartzose-schists, and crystalline limestones, filled with mica, hornblende, and other secondary minerals. The rocks of this series are usually evenly bedded, and are conformable with the overlying formations. Rocks consisting of slates, quartzites, and conglomerates, probably referable to the Lower and Middle Cambrian, are the next in succession. They have a thickness on the Omenica of about 4,000 feet. Grayish bedded limestones, holding corals, brachiopods, and other fossils characteristic of the Banff or Devono-Carboniferous division of the Bow River section, occur in the eastern ranges of the Rocky Mountains; while near the centre of the range, lower beds, probably Silurian in age, holding *Halysites catenulatus* were found in one place. Volcanic foliated schists and associated rocks, probably of Upper Palæozoic age, were found exposed along the Omenica. Triassic beds with *Monotis subcircularis* occur in the second range of the Rocky Mountains. Tertiary (Upper Laramie) beds, consisting of conglomerates interbedded with shales and sandstones, occupy the bottom of the valley of the Finlay. Some leaves and other plant-remains were yielded by the shales, and were determined by Sir J. William Dawson. The genera represented were *Arundo, Sequoia, Populus, Platanus, Quercus, Grewia* or

Grewiopsis (allied to *Tillia*), *Viburnum*, *Carpolite* (resembling *Leguminosites arachnoides*, Lesq.).

Evidences of glaciation abound throughout the district. In the Peace River Pass, well-marked groovings occur on the south side of the river, two miles east of Mount Selwyn. The movement of the ice here was eastward. The glacial deposits consist of Boulder-clay, accompanied by gravels, sands, and silts.

Gold has been obtained in the Omenica region, principally from the gravels overlying the older rocks, in the beds of the present streams. No deep diggings or extensive hydraulic workings have so far been attempted in this district.

Mr. D. B. Dowling presents his report (pp. 1 F to 54 F) on the country in the vicinity of Red Lake and part of the basin of Berens River, Keewatin. This district has an area of 6,300 square miles, the larger part of it forming a basin draining to the south to English River, and thence to Lake Winnipeg. The northern portion drains northward to Berens River, and thence westward to Lake Winnipeg. After detailing the physical features of the country, the writer describes its geological characters. The rocks exposed are all Archæan, consisting of gneisses and associated granites, classed generally as Laurentian, and folded schists and greenstones of the Huronian. In many respects these rocks are counterparts of those in the districts further south on the Lake of the Woods and Rainy Lake. Glacial action is shown in this area on the surfaces of the Archæan rocks, which are all more or less rounded and sometimes polished.

The report made by Dr. R. W. Ells (pp. 1 J to 157 J) treats of a portion of the province of Quebec comprised in the south-west sheet of the "Eastern Townships" map (Montreal sheet), with a chapter on the Laurentian, north of the St. Lawrence River, by Dr. Frank D. Adams. This is classic ground to the Canadian geologist, explorations having been carried on here almost from the beginning of the geological survey of Canada.

The sequence of the rocks (in descending order) represented in this region is as follows:—

Superficial deposits.
Devonian of Memphremagog Lake.
Silurian of St. Helen's Island, Montreal, Lower Helderberg, and of the St. Lawrence Valley, presumably Medina.
Cambro-Silurian: Lorraine (Hudson River formation).
,, ,, Utica.
,, ,, Trenton and Black River.
,, ,, Chazy-Trenton, east of the Sutton Mountains axis, Farnham, etc.
,, ,, Chazy.
,, ,, Calciferous.
,, ,, Potsdam sandstone of the Ottawa and St. Lawrence basin.
Cambrian: Sillery red and green slates, sandstones, and grits. Black and grey slates, east and west of the Sutton Mountain anticline.
,, Georgia series of St. Armand (Lower Potsdam of the "Geology of Canada," 1863).
,, Lower Cambrian of the Sutton Mountain anticline.
Pre-Cambrian: Huronian of the Sutton Mountain anticline.
,, Laurentian limestone and gneiss, west of the St. Lawrence River.
Crystalline and igneous rocks, volcanic and plutonic.

Areas of Devonian rocks occur at several widely separated points east of the Sutton Mountain anticline and its extension northward. The only outcrops of strata holding typical Devonian fossils are found on the western shore of Memphremagog Lake.

The areas of Silurian rocks found in this portion of the province of Quebec are of limited extent. They comprise the basin in which the lower part of Lake Memphremagog is situated, which is probably the largest development of Silurian strata in south-western Quebec, and outcrops of very limited extent are found also on St. Helen's Island, Montreal, while in the flat country to the east of the St. Lawrence, and to the south-west of Becancour River, Silurian rocks of an older horizon occur. The structure of the Silurian in the eastern or Memphremagog Lake area is that of a folded basin, resting, on either side of the lake, upon fossiliferous Cambro-Silurian or Lower Trenton rocks. The rocks of the whole series have been subjected to great metamorphic action since their deposition, for they are highly inclined and folded, and also cut by numerous dykes, often of large size.

The complicated structure of the Cambro-Silurian rocks of south-western Quebec has given rise to much controversy, and its elucidation throws some light upon the much disputed question as to the age of the rocks of the city of Quebec, of the Island of Orleans (in the St. Lawrence below Quebec), and at many points along the Lower St. Lawrence, as also upon the age and equivalents of the fossiliferous Lévis and Sillery divisions of the Quebec Group. The district is traversed by extensive faults, among which is the great St. Lawrence and Champlain fault, described by Sir William Logan in the "Geology of Canada," which has been traced from the Vermont boundary, at the foot of Lake Champlain, to the city of Quebec, and thence down the St. Lawrence River along the north side of Gaspé Peninsula. The result of recent researches, in which palæontology has played an important part, is to show that the stratigraphical sequence of the various divisions of the Quebec Group. as interpreted by Logan, must be completely reversed, and the divisions must now be read upwards from Sillery (Upper Potsdam), Lévis, and lower Phillipsburg (Calciferous), upper Phillipsburg, Bedford, and Mystic (Chazy), and Farnham black slates and limestones (Lower Trenton).

The classification of certain areas in the south-western portion of the province as Cambrian rests, to a large extent, upon stratigraphical position and lithological characters, though in regard to the position of most of these rocks in the geological scale there can be no doubt. The rocks consist mostly of red and green and blackish-gray slates, and sandstones, which are quartzose in some places.

The pre-Cambrian rocks east of the St. Lawrence are represented in the Sutton Mountain range (an extension into the province of Quebec of the Green Mountains of Vermont), and at other places in this area described in Dr. Ells's report. The Sutton Mountain rocks consist of crystalline schists, which are gneissic, micaceous, quartzose, and talcose in the central portions of the range, or that in which the axis of the anticline is situated; while the flanking rocks are green, chloritic schists; these extend from the Vermont boundary to the St. Francis in the vicinity of Richmond, and they are also recognized at various points on the eastern slope of the range.

Volcanic and plutonic rocks, including granites, syenites, diorites, dolerites, diabases, serpentines, traps, etc., evidently of different ages, are met with. They occur in low-lying outcrops, or they may rise into elevations, and constitute some of the most prominent mountains in the province of Quebec.

The Laurentian area in the north-west corner of the sheet comprising Dr. Ells's report is described by Dr. F. D. Adams. It forms a portion of the southern margin of the great northern "protaxis" of the continent, and thus represents a part of an extremely ancient land area, from the waste of which the clastic Palæozoic strata to the south were derived. The area here described, amounting only to about 400 square miles, is about equally divided between the rocks of the Laurentian system and intrusions of anorthosite which break through them.

The Laurentian consists of red and gray orthoclase gneisses, presenting great variations both in structure and composition, with which are associated crystalline limestones, quartzites, and amphibolites. Certain parts of the area can be recognized as belonging to the "Grenville series" of Sir W. E. Logan. This consists typically of an upper series of crystalline limestones, quartzites, and gneisses, having the chemical composition of ordinary sediments and a preponderating banded structure. There is also a lower series of gneisses, in which there are no limestones, etc. The latter is known as the Fundamental Gneiss, and it is this which is probably represented in the region described by Dr. Adams. Breaking through the gneisses are four masses of anorthosite, which are now known to be intrusive. Although intruded through the Laurentian at a time long preceding the Potsdam, the appearance of these anorthosites antedated at least the termination of the great earth-movements which affected the Laurentian in pre-Potsdam times, so that they have been squeezed and foliated together with the gneisses through which they cut. On the upturned edges of these deeply eroded Archæan rocks, both gneiss and anorthosite, the Potsdam sandstone and other Cambro-Silurian rocks repose in flat and undisturbed beds.

A voluminous Appendix by Dr. H. M. Ami, Assistant Palæontologist, concludes Dr. Ells's report. The Appendix contains preliminary lists of the organic remains occurring in the various geological horizons referred to in the report. Short descriptive notes on some of the fossils enhance considerably the value of these lists, and testify to the experience and assiduity of their compiler.

Mr. Robert Chalmers' report (pp. 1 M to 149 M) on the surface geology of eastern New Brunswick, north-western Nova Scotia, and a portion of Prince Edward Island, contains a detailed account of this area, which is described as "one of the most interesting and

rtant fields of investigation to be found in Eastern Canada,
as regards its surface geology and its agricultural resources."
ation is naturally devoted in this report to glacial phenomena
ll kinds, the data demonstrating the existence and action of
ing ice in the Pleistocene are summed up, and changes of level
ng the later Tertiary and post-Tertiary periods investigated.
physical features of the Bay of Fundy with its remarkable
are discussed, and their origin explained. The account of the
lder-clay and boulders is followed by a long list of glacial
e with their bearings and elevations. The latter are
trated in plates ii, iii, and iv. (Plate i has been left out
plate iii duplicated.) The author traces out local Pleistocene
iers in the Baie des Chaleurs, the St. John River Valley,
the isthmus of Chignecto; and, summarizing his results,
s that at the period of the maximum extension of the ice,
e was a general radial movement from the main nevé ground
he north-east Appalachians, northward and eastward into the
Lawrence Valley, eastward into the south-western embayment
he Gulf of St. Lawrence, south-eastward into the Bay of Fundy
Atlantic Ocean, and southward and south-westward into United
es territory. The occurrence of peat-bogs, dunes, and salt-
shes is noted, and a description given of them. Two sketch-
s showing (in colour) the areas occupied by Pleistocene
iers, and the striation from local glaciers and floating ice,
mpany the report.

r. G. Christian Hoffmann (pp. 1 R to 68 R) reports upon the
ion of Chemistry and Mineralogy, while the division of Mineral
istics and Mining for the whole Dominion is embodied in
E. D. Ingall's report for 1893 and 1894 (pp. 1 s to 187 s). The
k of this last report is sufficient evidence of the great efforts now
g put forth for the development of the mineral wealth of the
ninion.

laps (eleven in all) of parts of British Columbia, Quebec, New
nswick, and Nova Scotia, and Prince Edward Island, illustrating
reports of those regions, are issued with the volume, at the end
which there is a good index.

Dr. Dawson and his coadjutors may well be congratulated upon
s valuable addition to our knowledge of the geology of the
nadian Dominion.

ARTHUR H. FOORD.

.—AN INDEX TO THE GENERA AND SPECIES OF THE FORAMINIFERA.
By C. D. SHERBORN. Part II: NON to Z. (City of Washington: Smithsonian Institution, 1896.)

HIS is No. 1031 of the "Smithsonian Miscellaneous Collections,"
and completes C. D. Sherborn's Index of the Foraminifera, of
ich the First Part was published in 1883, through the liberality of
e Smithsonian Institute. The dates of the writers on recent and fossil
raminifera and their multitudinous, often confused Nomenclature,
ferred to in this elaborate Index, range from about 1565 to 1889.
lready, in the GEOLOGICAL MAGAZINE, Mr. Sherborn's careful and

valuable Bibliography of the Authors was noticed in January, 1889; and the First Part of the still more elaborate Index in August, 1894.

The two Parts, in 429 pages, contain at least 20,000 published names of the genera, species, and noticeable varieties of Foraminifera; and pages 480–5 are full of additions and critical corrections, due in great part to the enthusiastic research and kind help of Mr. F. W. Millett, of Marazion. This friendly aid, as well as the assistance given by other sympathizers in this important work, is thankfully and cordially acknowledged by the author in the Introduction to Part II.

A general idea of the value of such a synoptical and alphabetical catalogue of the multitudinous names given to these microzoa—often duplicate or triplicate, and to be found, in many instances, only in some rare or obscure periodical—can certainly be formed by any biologist, after even a short consideration of the circumstances. In actual experience, however, a monographist, desirous to do full justice both to species and species-makers, can estimate its real value by the saving of time and labour, which would have had to be spent in various libraries, often far apart, whilst hunting up references, often dubious and disappointing, and following professed clues, whether to real, or probable, or merely possible good results, or to the desiderated author or species.

Like the rest of Mr. C. D. Sherborn's bibliographic work, this Index is industriously complete and conscientiously exact, as far as circumstances have permitted. It is to be hoped that Mr. Sherborn, either by himself or with others, will carry on his work of ploughing up this wide field of nomenclature, and turn up both the rich soil and the troublesome clods, old and new, ready for the student, and open to the light of criticism.

V.—The Detection and Measurement of Inflammable Gas and Vapour in the Air. By Frank Clowes, D.Sc., etc. With a Chapter on the Detection and Measurement of Petroleum Vapour, by Boverton Redwood, F.R.S.E., etc. 8vo, pp. xii and 206, one plate and 49 diagrams. (London: Lockwood and Son.)

COAL and petroleum are of great interest to the geologist in many ways, and have been carefully studied as to their natural occurrence, their probable origin, their special localities, the means by which they are obtained, and the methods of their use: and geologists have had much to say on these points. Of course, the combustibility of coal and petroleum give these substances their peculiar value to the world at large; and, on account of the dangerous explosive powers of their derivative gases and vapours, these latter have had to be carefully studied by chemist and physicist.

The best methods of determining the presence of such gases in the air is the object of this book, which gives a carefully considered resumé of what has been done in this line of research. The inflammable gases concerned are Methane (Marsh-gas or Fire-damp), Coal-gas, Water-gas, Hydrogen, Carbonic Oxide (Choke-damp), Ethylene, and Acetylene; and their conditions of explosion ien mixed with air are first of all stated; also the influence of st on the explosibility. Then follows a historical summary of thods of gas-testing used in coal-mines, more particularly by est-flame" and "flame-cap," whether with oils, alcohol, or drogen. The hydrogen-flame, however, is considered to give e best results. It has, indeed, been found practicable to introduce into an oil safety-lamp, so as to supply a "standard flame" and a distinct "flame-cap"; and to supply a light even when the oil-ick fails to burn. It is specially adoptable for testing the coal-nkers on board ship, which are so often the source of destructive res and explosions. Test-chambers and other apparatus for exerimenting with flame-tests on known and unknown mixtures of ir and gases are fully explained and illustrated.

Amongst the combustible gases carbonic acid is here included; nd Dr. Haldane's researches on the poisonous properties and he detection of this gas (carbon-monoxide) are summarized pp. 130–145). Carbonic acid gas (carbon-dioxide) is also dealt rith, as often present with combustible gases, and as being a product f their burning or explosion.

A very important chapter follows on the detection and measurement of the vapour of petroleum in the air (by B. Redwood), pp. 168–197; particularly in the steamers carrying petroleum in tanks, and in the holds of vessels carrying or that have carried casks of petroleum.

A classified bibliography of papers relating to the subject of this useful book is added (pp. 198–200), and an index is appended.

T. R. J.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 2. 1896.—Dr. Henry Hicks, F.R.S., President, in he Chair. The following communications were read:—

1. "Another Possible Cause of the Glacial Epoch." By Professor Edward Hull, LL.D., F.R.S., F.G.S.

In the introductory portion of the paper the author gives an ccount of the submarine topography of the area east of North America, and summarizes Dr. J. W. Spencer's work upon a submerged Antillean continent; he then deals with the effects which would be produced upon the Gulf Stream by the uprising of this continent in the Glacial Period, and maintains that, as the current could not pass into the Gulf of Mexico (being debarred by a coast of high continental land), it would flow directly northwards into the North Atlantic, and thereby be deprived of about 10° (Fahr.) of heat: the effects of which may be practically illustrated by supposing the isothermal line of 32° to take the place of that of 42° in the northern hemisphere. He argues that the increased snowfall which would thus be caused over certain areas would tend to intensify the cold through all the adjoining tracts.

To the effects produced in this way must be added those due to the elevation of the land of Eastern North America and to an elevation of North-Western Europe, which is supposed to have occurred at the end of Pliocene times. These elevations would intensify the glaciation caused by the difference of direction taken by the Gulf Stream.

2. "On the Affinities of the Echinothuridæ, and on *Pedinothuria* and *Elikodiadema*, two new Subgenera of Echinoidea." By J. W. Gregory, D.Sc., F.G.S.

The author summarizes and discusses the literature bearing upon the Echinothuridæ, and brings forward arguments to prove that the family is a member of the order Diademoidea, and is derived from the Pedinidæ, members of which are found in earlier rocks than the Corallian, which contains the oldest member of the Echinothuridæ, namely, *Pelanechinus*. He maintains that the extreme flexibility and loose articulation of the plates of the living genera *Asthenosoma* and *Phormosoma* are due to the diminished calcification of the plates, and that these recent genera are extremely specialized forms, and not primitive—the apparently primitive features of the family being secondly acquired, not primæval.

A description is given of forms belonging to two new genera, described as *Pedinothuria*—a connecting-link between the Pedinidæ and Echinothuridæ; and *Elikodiadema*—which has a flexible test, is a modified form of *Pseudodiadema*, and has probably arisen from the adoption of a deep-sea life resulting in diminished calcification of the test.

3. "On *Echinocystis* and *Palæodiscus*, two Silurian Genera of Echinoidea." By J. W. Gregory, D.Sc., F.G.S.

The author gives a history of the genera *Echinocystis*, Salter, and *Palæodiscus*, Wyv. Thoms., redescribes their structures, and discusses their affinities. He concludes that *Echinocystis* is an echinid and not a cystid; and that *Palæodiscus* is an echinid and not an asterid. In order to prevent confusion, he suggests the name *Scolocystis* for a true cystid which was described by Hall as *Echinocystis*, some years after the latter name had been applied by Wyville Thomson to the fossil now concluded to be an echinid; and also suggests the name of *Discocystis* for the form named *Echinodiscus* by Worthen and Müller.

In discussing the affinities of *Echinocystis*, Wyv. Thoms., the two latest diagnoses of the Cystoidea (those of Professor von Zittel and Professor Haeckel) are considered, and it is contended that they do not enable us to draw any sharp line of distinction between cystids and echinids.

It is shown that the masticatory apparatus of *Palæodiscus* and *Echinocystis* explains the origin of that structure in gnathostomate echinids; and furthermore, it is suggested that *Echinocystis* renders probable the homology of the so-called "calycinal plates" of the Echinoidea with the plates of the valvular pyramid of the Cystoidea, and not with the calyx-plates.

The author gives synopses of the order Cystocidaroidea of Prof. von Zittel, and of its two families, Palæodiscidæ and Echinocystidæ.

II.—**December 16, 1896.**—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Subdivisions of the Carboniferous Series in Great Britain, and the True Position of the Beds mapped as the Yoredale Series." By Dr. Wheelton Hind, F.R.C.S., F.G.S.

In this paper the author gives a summary of our knowledge of the local divisions of the Carboniferous system, and criticizes the present classifications in vogue, laying special stress upon the local variations in the lithological characters of the rocks, and summing up to a large extent the fossil evidence which is available. He maintains that the Yoredale Beds are largely the equivalents of the beds which have elsewhere been referred to the Mountain Limestone Series, though some local beds which have been included in the Yoredale Series may rather be the equivalents of the Millstone Grit. He advocates the abolition of the term "Yoredale Series" as applied to a subdivision of the Carboniferous strata comparable in importance to such divisions as Carboniferous Limestone and Millstone Grit, but believes that the term may be usefully employed to denote the changes in character of the beds due to causes which operated locally, and to represent the Carboniferous Series as it occurs in Wensleydale, Swaledale, Teesdale, and the upper parts of Wharfedale and Ribblesdale.

He would divide the rocks of the Carboniferous system into an Upper Carboniferous or Anthraciferous Series, and a Lower Carboniferous or Calcareous Series; and indicates the occurrence of three very different faunas in the Carboniferous rocks, viz.: (i) a Coal-measure fauna rich in fish-remains, with the molluscan genera *Carbonicola*, *Anthracomya*, and *Naiadites* (essentially a fresh-water fauna); (ii) the Lower Coal-measure and Grit fauna, largely marine but littoral, with *Aviculopecten*, *Posidonella*, *Nautilus*, *Goniatites*, and peculiar gasteropoda; and (iii) a Limestone fauna essentially marine, very rich in brachiopods, and containing *Pecten*, *Avicula*, *Edmondia*, *Sanguinolites*, and many other lamellibranchs, gasteropods, such as *Euomphalus*, *Pleurotomaria*, *Murchisonia*, and *Loxonema*, and certain peculiar cephalopods.

2. "Notes on Volcanic Bombs in the Schalsteins of Nassau." By Professor E. Kayser, Ph.D., For. Corr. G.S. (Communicated by the Secretary.)

The bombs forming the subject of this communication occur in two localities in the neighbourhood of Oberscheld, near Dillenburg. They are generally rounded, though sometimes angular, and vary in size from that of a nut to that of a man's head. Each consists of a kernel of coarse-grained rock representing a fragment of limestone altered by metamorphism, surrounded by a rind of amygdaloidal rock due to the inclusion of the fragments in molten lava. They demonstrate the pyroclastic origin of the Schalsteins, and also prove the similarity between the old Devonian volcanoes and those which are now active.

III.—January 6, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Structure of the Skull of a Pliosaur." By C. W. Andrews, Esq., B.Sc., F.G.S.

The paper deals with a specimen of the Plesiosaurian known as *Pliosaurus ferox*, Sauvage, obtained by Mr. A. N. Leeds from the Oxford Clay near Peterborough, and now in the British Museum, and perhaps the finest Pliosaur skull known. It bears a great similarity to *Peloneustes philarchus*, but there are a number of differences which tend to show that the subject of the present communication is not the skull of an old individual of *Peloneustes*. Although the teeth of the fossil here described agree precisely with those described by Sauvage from the same horizon at Boulogne under the name *Liopleurodon ferox*, they differ considerably from those of the Kimmeridge Clay upon which Owen founded the genus *Pliosaurus*; they, however, show a distinct tendency towards the typical form, and since the skull and skeleton of the Oxfordian and Kimmeridgian forms are, so far as known, closely similar, the author prefers for the present to follow the British Museum Catalogue in referring them both to one genus, *Pliosaurus*.

The author gives a detailed description of the skull which forms the subject of the paper.

2. "On the Pembroke Earthquakes of August, 1892, and November, 1893." By Charles Davison, Sc.D., F.G.S.

Part I of this paper deals with the earthquakes of August, 1892, of which eleven are recorded, the principal being the third. The author gives an account of the preliminary shocks and after-shocks, and a detailed account of the principal earthquake, describing the disturbed area, the relationship of the earthquake to a north-and-south fault, hading to the west, that of sound to shock, and the occurrence of sea-waves.

Part II treats of the earthquakes of November, 1893; there were four undoubted earthquakes, of which the first was the chief one. Descriptions are given of the phenomena.

Part III treats of the origin of the earthquakes and their connection with faults; and the author points out the possible value of the study of earthquakes in supplementing geological surveys. For more than fifty years prior to the earthquakes of 1892–3 there appear to have been no slips of importance along the fault-system of the area. After this prolonged interval of repose, the earlier movements took place along transverse (north-and-south) faults, and the later along longitudinal (east-and-west) ones. The three faults of the latter series which the author connects with the disturbances lie successively one to the north of the other, as if the abrupt displacement of a rock-mass over one thrust-plane impelled the advance of those immediately below. There can be little doubt that the fault-slips of 1892 affected the conditions of stress along the neighbouring transverse fault, so that the displacements along it occurred earlier than they might otherwise have done.

3. "Changes of Level in the Bermuda Islands." By Professor Ralph S. Tarr. (Communicated by the Secretary.)

The author gives a summary of previous writings bearing upon the geology of the Bermudas; but his own researches point to a rather more complicated series of changes than those which have been inferred by other writers. The formation of the "base-rock" or "beach-rock" occurred at some period which cannot be accurately ascertained at present, owing to the fragmentary nature of the included fossils. It may have been formed in Pleistocene or even late Tertiary times. After its formation it was converted into a dense limestone and then eroded, probably by subærial agents, and finally attacked by the waves at an elevation of at least 15 feet above present sea-level; during this stage it was covered by beach-deposits of pebbles and shells, which were accumulated in a period so recent that the contained fossils are of the same species as the organisms living in the neighbouring sea. Then followed an uplift, during which land-shells lived on the beach-deposits; but these were soon covered by blown sand, the principal accumulations of the islands, and the outline of the islands was perfected by the action of the winds. This was done at an elevation which was at one time certainly as much as 40 or 50 feet above present sea-level. The author adduces evidence of a depression since the accumulation, causing land to disappear and the outline of the area to become very irregular; and he proves that these changes cannot be accounted for solely by erosion, as some have maintained. There are indications that the land is at present quiescent. It appears, then, that most of the work of construction of the Bermudas has been done in recent times.

CORRESPONDENCE.

INDICATIONS OF EARTHQUAKE.

Sir,—The accounts of the recent earthquake which I have seen in an English paper, include references to the accompanying sound as resembling the noise "of a rushing wind." This recalls an observation of my own showing that the appreciation of such sounds varies at times from the subterranean or other rumblings so often recorded.

It was early in the seventies when I was reading over the fire one night in my "den" at Devonshire Cottage, Murree, elevated about 7,000 feet on the foot-hills of the Punjab outer Himalaya. The fire had burned low in a grate surmounted by an arch cut from a sandstone slab, which was cracked upwards from the crown, and for more warmth I had placed my feet against the slab on each side of the crack. A little later I noticed a "soughing" or sound of "rushing wind," as I thought, coming up the valley from Trêt, through the pine forests. Thinking this strange on a calm night I looked up and over my book, when I distinctly felt the motion of one of the small earthquakes not very uncommon in the Upper Punjab, and saw the old crack referred to open between my feet for more than half an inch, and close as the seismic wave passed onwards.

It may be this which fixed the character of the sound in my memory; at any rate, I do not recollect another earthquake accompanied by the sound of "rushing wind."

Davas Darf, Suisse,
December 19, 1896.

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DR. WHEELTON HIND'S CARBONIFEROUS LAMELLIBRANCHIATA—PART I. INTRODUCTION (PALÆONTOGRAPHICAL VOLUME, 1896).

SIR,—Under the heading of "General Sequence of the Carboniferous Rocks," which embraces analyses or divisions of some of the coalfields in Britain, reference is made to the succession of the rocks in the Coal-measures in Somersetshire, or the southern part of the Bristol Coalfield. *Under* the general term Coal-measures, in the division "UPPER," are placed—(1) The *Radstock and Farringdon* Series; (2) The *New Rock and Vobster* Series: both these are classed as belonging to the *Upper* Group of Coals.

The Radstock and Farringdon Series are undoubtedly members of the Upper Coal-measures, and of the uppermost division in Somersetshire; but the *New Rock* and *Vobster Series*, or coals, are in the *lowest* part of the *Lower Coal-measures*,—the two series being separated by *nearly* 2000 *feet* of the well-known "*Pennant* Sandstone," so that the *term Upper* is here most misleading. Between the lines Radstock and Farringdon Series, should be inserted the "MIDDLE OR PENNANT SERIES, or *Sandstones*" (2000 feet thick). The term "Millstone Grit" has no value here, unless the *New Rock* and *Vobster Series* (coals) are inserted below the Pennant and above the Millstone Grit, in the *Somersetshire* portion of the Bristol Coalfield, the northern and southern areas forming one continuous field. We can hardly understand how the northern and important division of the Bristol and Somerset Coalfield was omitted in the sequence. The entire basin is 26 miles from north to south, and 8 to 10 miles from west to east, but continuous and almost unbroken, the sequence being the same in either case, the Carboniferous Limestones and coal shales being highly fossiliferous. The Bristol Coalfield is the most typical and perfect in stratigraphical succession of any of the coalfields in Britain. I draw Dr. Wheelton Hind's attention to this very important omission in order that he may make his monograph upon the fossils of the British Carboniferous rocks for the Palæontographical Society as complete and accurate as possible, and that he may be induced to look carefully into the true succession of the different areas that will come under his examination. R. ETHERIDGE.

OBITUARY.

DAVID ROBERTSON, LL.D., F.L.S., F.G.S.

BORN NOVEMBER 28, 1806. DIED NOVEMBER 20, 1896.

DAVID ROBERTSON, once upon a time the little herd-boy of a Lanarkshire moorland farm, by-and-by the successful Glasgow merchant, and then for thirty or forty years the keen, shrewd, patient observer, bent on the acquisition and furtherance of "natural knowledge," has passed away, after a life that has still been "too short for friendship," although so greatly prolonged. He was born in 1806, November 28 of the Old Style; he died in 1896, November 20 of the New Style, and therefore just within three weeks of finishing his ninetieth year. It must not be fancied from his age that his claim to be noticed in this Magazine depends on his having become, as is sometimes the result of longevity, a breathing fossil. On the contrary, his scientific activity was maintained unflinchingly to the end. He became a Fellow of the Geological Society of London in 1869, but he had joined the Geological Society of Glasgow two years earlier. To the Quarterly Journal of the former he contributed but one short paper; to the Transactions of the latter a long series of Essays, many of them in collaboration with the late Dr. Crosskey on post-Tertiary Clays. Together with G. S. Brady and Crosskey, he compiled for the Palæontographical Society an important Monograph on the post-Tertiary Entomostraca of Scotland.

In the words of Mr. Dugald Bell, Robertson's work in geology was distinctively that of a zoologist, but characterized, like all his other work, by its minute and painstaking thoroughness. "He seldom, if ever, meddled with questions of stratigraphical or physical geology. In conversation he sometimes 'beat over' certain points in glacial geology, and his statement of doubts and difficulties here and there was always very suggestive. But he always fell back upon his labours to unfold the *life* of the period as far as possible, in all its varieties, even the humblest. The principal observations of a more general kind, relating to what may be called physical matters, which I remember as coming from him, are (1) his note on the accelerated precipitation of sediment in salt-water as compared with fresh; and (2) his remark that a lighter or browner colour of the Upper Boulder-clay, as compared with the Lower, was due very frequently at least, not to any difference in materials or in conditions of deposition, but simply to the action of the weathering agencies to a certain depth from the surface on the ferruginous elements contained in the clay. These observations were wrought out with great clearness, and have been very helpful in some points." (Mr. Dugald Bell *in litt.*)

From 1892 onwards Robertson was on a Committee of the British Association for investigating certain shell-bearing clay deposits in various parts of Scotland. When a man of eighty-six is placed on such a committee, it might well be supposed to be done out of pure compliment, or for the countenance of a distinguished name, or at most to add the authority of an experienced judgment to the results of younger men's labour in the field. A far different view of the responsibility was taken alike by those who selected Robertson, and by the man of their choice. Each year a substantial part of the report has been from his pen. Each year a substantial part of the work has been accomplished by his exertions. He undertook the preparation of the samples of clay, and the determination of the various organic remains, many of them extremely minute or fragmentary, which resulted from the careful washing, straining, and separating of the constituent gravel, sand, and mud. The tediousness of the occupation none can know but those who have tried it. In private correspondence Robertson would speak of the more congenial employments he would be at, "when," as he phrased it, "I am out of the mud." His last report on this subject, printed but not yet published, has, as Mr. Bell says, "a pathetic interest now as being the last work from his hand." The foundation of it was laid in an excursion to Tangy Glen and Cleongart Glen, in company with Messrs. Horne and Bell, in the summer of 1895. In a letter dated June 6, 1895, he gave the present writer an account of that expedition. Much of it was by carriage, but by no means all. Thus, in reference to Cleongart Glen, the geologist verging upon eighty-nine observes that "Here we had, when we left the road, some steep climbing, and at places we had to make sure of the hold of one foot before we ventured to bring up the other." He admits, with his accustomed modesty, that he could not walk quite so fast as his companions. So, to save time, when the inspection was over, he left them to do the packing-up, and started in advance. On his solitary way back he entered a large field in which were a number of cows with a bull. The "lord of the harem," displeased at intrusion, came "crooning" towards him. No harm followed, for the bull's attention was presently distracted by the appearance of the other geologists in a different quarter and by the advance of the placid members of his own family. Meantime Robertson was not leaving his fate to the chances of external succour; for, as he explains in a subsequent letter, being on the edge of a nearly precipitous bank, he was prepared to slip down on to a platform roomy enough for his two feet, but "where a bull could not have found footing for four." From this and similar, more or less laborious, excursions he returned in excellent health, with clay enough to last him for months. On May 1, 1896, he writes: "I expect I will have to go to Campbelton some time about the middle of this month, to endeavour to settle, if possible, a long-standing contention whether shells met with in clay beds four or five hundred feet above the present sea have lived and died where they are found, or have been transported there by ice action. I believe in the former, and I am hopeful that the conditions of the Campbelton shelly clay beds will put that beyond dispute, and further explain the relations between the laminated shelly clay and the Boulder-clay."

In April, 1895, the University of Glasgow conferred upon David Robertson, in company with Lecky the historian and other distinguished men, the honorary degree of Doctor of Laws. It was a fine and, as it has proved, a timely recognition of Robertson's enduring devotion to science. The honour came late, as it was likely to come, if it ever came, to a man whose unassuming simplicity of character made him far more anxious to do creditable things than to win credit for the doer. Robertson's heart was perhaps even more wrapped up in marine zoology than in geological subjects; but that is another story. He was a delightful friend. He was a sterling man. He passed through many changes of fortune, and knew how to make himself happy and beloved in all.

T. R. R. S.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IV.

No. III.—MARCH, 1897.

ORIGINAL ARTICLES.

I.—GEOLOGY OF THE LONDON EXTENSION OF THE MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY. PART II: RUGBY TO QUAINTON ROAD, NEAR AYLESBURY.[1]

By HORACE B. WOODWARD, F.R.S., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THE cuttings along this new line of railway from Annesley to a little south of Rugby have been described by Mr. Fox-Strangways, and it is now proposed to note the chief geological features along the line as far as Quainton Road, near Aylesbury. This portion of the railway crosses the country from north to south and south-east for a distance of about 35 miles. The following notes were made partly in November, 1895, when the cuttings were examined from Willoughby, near Rugby, to Helmdon; and partly in May of the following year, when the examination was continued to Quainton Road.

Traversing, as this railway does, a hilly country from 200 to nearly 600 feet above sea-level, and encountering over the greater part of the distance heavy clays, a considerable breadth of ground has been occupied, whether by cuttings or embankments. The cuttings have thus exposed a fine series of sections from Lower Lias to Oxford Clay, and also of Glacial Drifts.

Commencing about a mile north of Willoughby, near Braunston, and proceeding southwards, there are three shallow cuttings in the Lower Lias, showing stiff grey marly clay, overlain by fossiliferous clay with hard limestone-nodules. These nodules have assumed fantastic forms, like many chalk-flints, differing in a marked way from the smooth and somewhat ferruginous cement-stones found a little higher in the series. The occurrence of many Belemnites, together with *Gryphæa obliquata*, *Pecten*, *Plicatula spinosa*, and *Rhynchonella*, suggested that here we have equivalents of the strata at Fenny Compton, which long ago yielded so many fossils of the zones of *Ammonites armatus* and *A. Jamesoni* to the late Thomas Beesley, of Banbury. Further observations confirmed this view. The strata dip gently to the south, and the succeeding deposits comprise clays with ferruginous bands and selenite, and with small flat ferruginous cement-stones. Crossing the Oxford Canal at Wolfhamcote, these clays are found to yield *Ammonites Jamesoni*, *Belemnites*, and *Plicatula spinosa*. At a higher horizon the clays become stiffer and contain ochreous nodules with *Ammonites striatus*; they are equivalent to the beds at one time worked in the Braunston brickyard, where also *A. Valdani* was found. Along this part of the railway the clays were burned for ballast. A cutting about 20 feet deep, east of Nethercote, showed a continuation of these clays, which yield *Inoceramus ventricosus*, *Modiola scalprum*, *Unicardium cardioides*, and some Gasteropods. They evidently belong to the zone of *Ammonites capricornus*, the lower portion of which is sometimes marked as the zone of *A. Henleyi*.

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[1] The substance of this paper was communicated to the Liverpool Meeting of the British Association in 1896.

The late Professor A. H. Green, who had previously examined the cuttings from Nethercote to Charwelton, sent to the Museum of Practical Geology a number of fossils which he had obtained from an excavation in the low ground south-east of Nethercote. These were identified by Mr. G. Sharman and Mr. E. T. Newton, as follows :—

Ammonites Maugenesti, D'Orb.
Belemnites.
Avicula inæquivalvis, Sow.
Cardinia concinna, Stutchb.
——— *Listeri*, Sow.
Gryphæa cymbium, Lam.
Lima Hermanni, Voltz.
Ostrea.
Pecten æqualis, Quenst.
——— *æquivalvis*, Sow.
——— *lunularis*, Roem.
Plicatula spinosa, Sow.

The assemblage is interesting as indicative of the zone of *Ammonites Ibex*, which is rarely to be recognized in this country.[1] The fossils come from a position lower stratigraphically than those obtained from the Nethercote cutting.

Proceeding southwards we come to a cutting north of Catesby House, and at the northern entrance to the Catesby tunnel. Here about 12 feet of stiff dark-blue clays, overlain by grey clay with ferruginous septaria, were exposed. Tender pearly and iridescent fossils occur in abundance, and among those obtained by Prof. Green, and (subsequently) by myself, were *Ammonites capricornus*, *A. Loscombei*, *Avicula* (*Monotis*) *inæquivalvis*, *Arca* (*Cucullæa*) *Stricklandi*, *Cypricardia cucullata*, *Hinnites*, *Inoceramus ventricosus*, *Modiola scalprum*, *Pecten lunularis*, *Pleuromya costata*, and *Unicardium cardioides*. Meanwhile, Mr. Beeby Thompson has described in detail the cuttings between Catesby and Woodford,[2] and by his enthusiastic labours he has been able to publish very much fuller lists of fossils from the strata; and especially from the clays just mentioned, which belong to the zone of *Ammonites capricornus*.

The Catesby tunnel is rather more than a mile and a half in length, and is excavated partly in these clays, which are rich in Belemnites, and partly in the overlying laminated micaceous clays and sandy beds of the Middle Lias (zone of *Ammonites margaritatus*). The Marlstone rock-bed (zone of *A. spinatus*) is exposed above the el and at its southern entrance. Much of the material obtained the tunnel was brought up shafts and tipped along the high nd above the tunnel, and there an admixture of Lower and dle Lias fossils gave a certain amount of delight and some ow to the collector. The same difficulty in separating the fossils the two zones was experienced at the tunnel near Chipping ton, where similar strata were excavated, and where very fine nples of *Cypricardia* were obtained. At Catesby the abundant mmnites occurred in nodular layers with *Ammonites capricornus*; le *A. margaritatus*, *Pecten æquivalvis*, *Gresslya*, and *Cypricardia* obtained from blocks of grey calcareous sandstone, belonging ne Middle Lias. Mr. Thompson has recorded many other species the zone of *A. margaritatus*.

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[1] *A. Ibex* has been recorded from the Kilsby tunnel.

[2] Proc. Geol. Assoc., vol. xiv, pp. 422, 428.

. little to the south of Catesby tunnel, and east of Steppington ney, a fine section of the Middle Lias was exposed, as follows Fig. 1):—

Middle Lias.

Rubbly ferruginous limestone (Marlstone).
Ferruginous sandy clays, about 5 ft.
Blue-hearted calcareous sandstone with serpulæ, much jointed and waterworn, 3 ft. to 4 ft. 6 in.
Yellowish ferruginous clay.

e gentle southerly dip of the strata is modified to the south of s exposure, where the Middle Lias is brought abruptly against dark-blue clays of the Upper Lias. This fault is regarded by . Beeby Thompson as a reversed one: I saw nothing to indicate t this was the case, and, in fact, noted it as the northern portion a trough-fault which lets down a mass of Upper Lias clay between o tracts of Middle Lias. The hard rock-bed with serpulæ is of the ne character as a band noticed in the Middle Lias in a brickyard Twyford Lane, near King's Sutton.[1]

It is noteworthy that along the portion of the railway now scribed, which includes a part of the Lower Lias vale and of the ddle Lias escarpment, no Glacial Drift was exposed. A few artzite pebbles occur in the soil along the low ground west of aunston, but these are simply relics of post-Glacial denudation. seems probable that this tract, like the Marlstone scarp of Edge ll to the south-west, was not glaciated.

East of Charwelton Hall, at an elevation of about 500 feet, in ract bordered by somewhat higher ground near the source of the ver Cherwell, the Upper Lias clay is overlain by gravel 6 or 8 feet ick. Bordering the stream further south the deposit has been dug a depth of 20 feet. It is a rudely-bedded sandy gravel, with arse sand, and pebbles of flint, Chalk, jasper, quartz, quartzite, and onstone; together with derived Jurassic fossils, notably *Gryphæa mbium* of the Middle Lias and many Belemnites. It is interesting find that this deposit was noticed by Conybeare, who remarked: Near Charwelton there is a small accumulation of chalk flint ravel, and other alluvial débris in the bottom among the hills."[2]

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[1] H. B. W., "Lias of England and Wales," p. 225.
[2] "Outlines of the Geology of England and Wales," 1822, p. 248.

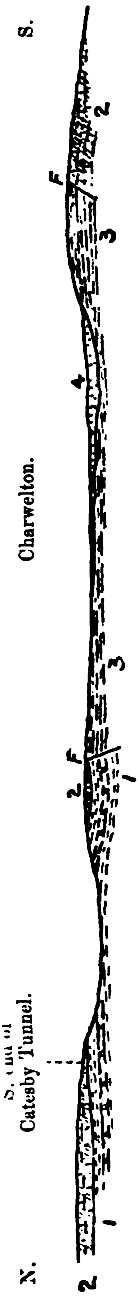

FIG. 1.—SECTION AT CHARWELTON, NORTHAMPTONSHIRE. (Distance = one mile.)

1. Clays with band of calcareous sandstone. } Middle
2. Rock-bed. } Lias.
3. Upper Lias.
4. Gravel.
F. Faults.

In the main this must be regarded as belonging to the Glacial Drift, although it may have been rearranged in places by the stream.

Further south, and to the east of Charwelton, the Upper Lias clay with *Ammonites fibulatus* is seen in the cutting faulted against the Marlstone, the newer formation occupying (as before mentioned) the trough, and rubble from the Middle Lias being washed over the clay-slope of the Upper Lias.

South of the river Cherwell, and to the north-east of Charwelton Lodge, there are shallow cuttings in stiff grey and yellow clay (Upper Lias), with a little gravel south of Blindpool Spinney; and near by there are ferruginous, sandy beds, a downwash on to the clay from the "Northampton Sands" of Hinton Hill. The sections here were much obscured at the time of my visit, but my observations accord with those of Mr. Beeby Thompson, who discovered estuarine sands with plant-markings, and attributed the position of the deposit to slips from the higher grounds of Hinton Hill.[1]

To the north of Woodford Halse, a cutting about 15 feet deep showed Upper Lias clay dipping gently towards the south. It contained two bands of ferruginous, earthy limestone, which became thinner towards their outcrop on the north. *Ammonites communis*, *A. bifrons*, and *A. serpentinus* (*falcifer*) occur here. Crossing the East and West Junction Railway to the south of Woodford Halse, we come to a cutting which showed Chalky Boulder-clay (3 or 4 feet) resting on an irregular bed of sand and loam, beneath which was a mass of stiff blue clay, with layers of fine chalk stones—the clay, no doubt, largely derived locally from the Upper Lias. This was the first mass of Glacial Drift encountered along the railway south of Willoughby, if we except the gravel before mentioned.

Further south, to the north-east of Eydon, fine gravel and gravelly loam were seen, resting on blue clay (Upper Lias). By Foxhall Farm, west of Moreton Pinkney, red sand was exposed, and a little further south there was an excavation showing ten feet or more of coarse gravel and sand, with one foot of stony ıy or loam on top. The gravel here consisted of flint, quartz, ɔnstone, Chalk, and Jurassic fossils.

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[1] Proc. Geol. Assoc., vol. xiv, p. 427.

South-west of Moreton Pinkney, the Chalky Boulder-clay covers considerable tract, and is exposed in the railway-cuttings, resting, n the north, near Foxhall Farm, on blue clay (Upper Lias). At anbury Lane, in the Barrowhill cutting, the Upper Lias was well xposed to a depth of 30 feet. It comprised stiff blue clay, yellow n top, with cement-stones, and it yielded few fossils except *lmmonites serpentinus* (*falcifer*) and Belemnites. In two cuttings urther south, to the north-east and east of Sulgrave, sands and clays elonging to the Estuarine Series beneath the Great Oolite Limestone ad been exposed, but the banks had been sloped. The strata were, owever, clearly to be seen west of Peter's Farm, north-west of Helmdon, where the following section was noted:—

Chalky Boulder-clay (on the higher ground).

Great Oolite Limestone and Estuarine Beds.	feet.
Sandy marl with *Rhynchonella*	2
Sandy and shelly limestone with *Ostrea Sowerbyi*, *Modiola*, and *Rhynchonella*	4
Sandy and marly clay with *O. Sowerbyi*, *Strophodus*	7
Bluish-black carbonaceous clay, merging into greenish clay	6
Stiff grey and white clay with rootlets and sandy seams	8

The stiff grey clay, which was well shown to the south-west of the Helmdon and Sulgrave road, might furnish a useful tile-earth or potter's clay. The beds overlying the black clay vary much in character, as the oyster-beds become in places solidified into stony layers. The strata beneath the Boulder-clay dip to the SSE., and nearer to Helmdon are overlain by a rubble of Great Oolite Limestone. The stone was worked at one time in quarries to the east of the railway.

South of Helmdon the Great Oolite Limestone was formerly quarried east of Grange Farm. To the south of this there is a cutting in the Great Oolite Series and overlying Chalky Boulder-clay. The strata were as follows:—

Chalky Boulder-clay (25 ft. thick by the bridge north of Glebe Farm).

Great Oolite Limestone and Estuarine Beds.	ft.	in.
Marls and thin clay-bands with *Ostrea Sowerbyi*, and marly limestone with many examples of *Pholadomya deltoidea*; sandy limestone at base	20 to 25	0
Brown sand with lignite and tender shells of *Ostrea*	1	8
Irregular clay-seam		
Brown sand and clay with *Ostrea*		
Dark-grey clay passing down into greenish-grey clay	4 to 5	0
Yellowish clay with rootlets	12	0

I mark no division between the Great Oolite Limestone and Estuarine Beds, as there is no constant horizon by which to define it. The yellowish clay with rootlets is evidently the same as the lowest bed noted in the section north-west of Helmdon; but beneath it, in the foundations for a bridge, nine feet of blue limestone with *Modiola* and *Trigonia* were proved. I was unable to devote time to collecting from this lower bed, but I am disposed to group it with the Great Oolite Series. The dark-grey and greenish clays are similar to beds which characterize the Upper Estuarine Series, and clays with rootlets, as well as layers with marine fossils, are well known to occur in that division.[1] The representatives of the Inferior Oolite are probably confined to sandy strata (Northampton Sand).

The details of the Public Well at Brackley, kindly communicated by Mr. R. J. Russel, do not help to elucidate the matter, although they serve to indicate the varying character of the beds between the Great Oolite Limestone and the Upper Lias. The well was sunk 60 ft. 6 in. and then bored, and the following strata were penetrated:—

		ft.	in.
	Soil	0	6
Great Oolite Series	Marl...	3	0
	Beds of limestone	23	0
	Callous clay	2	0
	Limestone beds and marl	19	0
	Callous clay...	2	0
	Rubble limestone	3	0
Northampton Sand	Red sand	3	0
	Black sand	5	0
Upper Lias ...	Very hard blue clay	101	0
	Stone	2	0
	Blue clay	6	0
Middle Lias ...	Stone	3	0
	Sand and hard clay...	8	0
	Mostly sand	4	0
	Very hard stone	3	0
	Sand and hard clay...	6	0
	Very hard stone	5	0
		198	6

Helmdon Stone was formerly held in repute, as, according to Morton,[2] it was used in the mansions of Stowe and Woburn; but for 150 years or more the quarrying of the stone for building-purposes appears to have been abandoned. Some specimens of the stone have been recently sent to the Museum at Jermyn Street by Mr. T. K. Curtis, of Brackley, and they consist of shelly oolitic and earthy limestone, evidently belonging to the Great Oolite. Judging previously by the old records, I had been led to regard the stone as of Inferior Oolite age.[3]

Chalky Boulder-clay was shown in the cutting east of Radstone, and to the south this Drift rests on clayey beds belonging to the Estuarine Series. Crossing the stream, we pass an old quarry where Great Oolite has been worked, and enter the cutting east of Hill Farm, where Boulder-clay five or six feet thick rests on Great Oolite Limestone. In places the Boulder-clay has been weathered into a brown stony loam, but, further on, its grey and chalky character is well seen, and some sections of considerable interest were opened up. Much of the Great Oolite Limestone is a soft, pale, earthy

[1] Judd, "Geol. Rutland," p. 189, etc.; H. B. W., "Lower Oolitic Rocks of England," p. 402.

[2] "Nat. Hist. Northants," 1705, pp. 108, 126.

[3] "Lower Oolitic Rocks of England," p. 475.

limestone resembling Chalk, and here and there it is by no means easy to mark any plane of junction between the Chalky Boulder-clay and the weathered rubble of Great Oolite. At one point there were streaks or strips of reddish-brown clay at the base of the grey Boulder-clay, and more or less parallel to the bedding of the rubbly Oolite below. A little further south the Great Oolite was disturbed and nipped up. Again further south, the Boulder-clay was seen resting on a piped surface of the Great Oolite, the pipes being filled with greenish clay, and with reddish-brown clay precisely like that incorporated in thin strips at the base of the Boulder-clay. (See Fig. 2.)

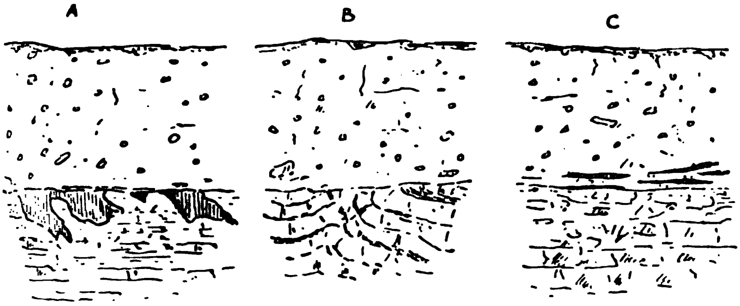

Fig. 2.—Sections East of Hill Farm, Radstone, Northamptonshire.
Chalky Boulder-clay resting on Great Oolite.
(A) Great Oolite with piped surface. (B) Great Oolite disturbed. (C) Strips of brown weathered clay at base of Boulder-clay.

Here evidently the agent which accumulated the Boulder-clay was forced over an old weathered land-surface of the Great Oolite. That formation was disturbed in places, and portions of the old soil were stripped off and included, with masses of the rubbly rock, in the Drift. In other places the Boulder-clay was accumulated evenly on the Oolite, the rubbly surface of which was planed off without producing any marked disturbance in the strata beneath.

At the southern end of this cutting, we pass sections of Boulder-clay with Oxfordian Gryphæas resting on Great Oolite marls, limestones, and *Ostrea*-clays, and then come upon a section of coarse Boulder-gravel and fine sand, exposed to a depth of 12 or 15 feet. The cutting had been partially sloped, and the connection was not very clearly shown between the Boulder-clay and the Gravel; but it was evident that the Boulder-clay abutted against a Gravel mound, the entire cutting (above the Great Oolite) to the north being in Boulder-clay, and to the south being Gravel. It was, moreover, possible to trace a thin course of Gravel underlying the Boulder-clay. The Gravel was rudely bedded, and consisted of Chalk, Oolite, flint, quartzite, and Carboniferous Limestone. Belemnites and the Oxfordian *Gryphæa dilatata* were noteworthy among the derived fossils. Blocks of rock up to a foot in diameter were present. In fact, the assortment of stones in the Gravel was such as might have been obtained from the Boulder-clay. It may be remarked that similar coarse gravels occur near Buckingham in association with the Boulder-clay, and near the margin of the area over which the ice which accumulated the Chalky Boulder-clay formerly extended.

South-west of Glebe Farm another cutting showed Great Oolite limestones and marls, the stone-beds being poor and rotten, with seams of pale greenish marl. These beds were burned for lime at the old kiln on the west side of the railway. Further on towards Brackley the top beds of Great Oolite are hard, even-bedded shell-limestones, like beds of Forest Marble; while below are banded white, brown, and grey marly beds, and soft marly limestones, 15 feet thick, the strata being locally disturbed by a number of tiny step-faults, the result, perhaps, of land-slipping. Underneath these beds were very fossiliferous, soft, white limestones and marls, with many specimens of *Pholadomya deltoidea*: also *Pecten annulatus*, *Cypricardia*, *Ostrea Sowerbyi*, and other Lamellibranchs; *Natica globosa*, *N. neritoidea*, *Terebratula maxillata*, and *Clypeus*.

Crossing the river Ouse, similar beds of Great Oolite were opened up, some layers of the rock resembling the Helmdon Stone before mentioned. The section in the cutting was as follows:—

	ft.	in.
Rubble and shivered beds of Great Oolite	10	0
Harder bands of limestone, with intermediate marl (2 or 3 feet); many fossils—*Pholadomya*, *Natica*, *Clypeus*, etc. ...	9	0
Banded marly beds and soft white limestone	10	0

The beds change in character somewhat rapidly, as soft, pale, marly limestones develop into harder stone-beds irrespective of clay-cappings. West of Grovehill Farm, a section of Great Oolite similar to that last mentioned was exposed.

It is noteworthy that no Drift occurred along the line of railway in the immediate neighbourhood of Brackley.

Crossing the Banbury branch of the London and North-Western Railway, we enter another cutting in Great Oolite. The uppermost beds were one foot of grey marl and "race," resting on hard shelly limestones (1 ft. 3 in.), like the beds north of Brackley; and the underlying beds were also similar, including grey clays and white fossiliferous oolitic limestones, with *Ostrea* abundant, *Natica*, and other fossils. An irregular bed of gravelly clay and ochreous sandy gravel, 2 to 15 feet thick, rests on the Oolite. Where the gravel is thickest, it has patches of Boulder-clay here and there at the base.

East of Mixbury there is a long shallow cutting in Gravel. At the northern end the Great Oolite, comprising a few feet of hard white limestone weathered into rubble, is overlain by grey clay, and this clay appears to belong to the Oolitic series. It contains a few pebbles, and these have in all probability been derived from the overlying Gravel. In dry weather, when clays become deeply fissured, stones from an overlying Drift or soil may drop into crevices and eventually become imbedded in the mass of the clay, even to a depth of four or five feet, or more. Portions of this long cutting show only thin gravelly loam four or five feet, or gravelly loam over gravel and sand six feet. By Widmore Farm there is ten or twelve feet of angular gravel and fine gravel and sand. The gravel consists of pebbles of quartz, quartzite, and Oolite, and but few of flint, the flint being mostly subangular. At the south end of Finmere Plantation the Boulder-clay appears from beneath a covering of sand and gravel, with a strong spring issuing at the junction. The relations of these Drifts are thus reversed, but the overlying gravel differs from the Boulder-gravel which elsewhere appeared beneath the Boulder-clay. The Boulder-clay here contains large boulders of Oolite, but these are not noticeable in the gravel. Gravel again occurs over the Boulder-clay at the southern end of the cutting. For some distance by the Barrow near Bartonhill Farm, west of Chetwode, Chalky Boulder-clay was the only formation exposed. South-west of Rosehill Farm it rested on fine buff sand, and a short distance beyond the Oxford Clay appeared.

No evidence of Cornbrash was found in any of the cuttings, the outcrop of this formation being concealed between Newton Purcell and Barton Hartshorn, Finmere and Mixbury, by Drifts.

Onwards by Twyford no sections of interest were exposed: only thin deposits of gravel and gravelly loam were seen on Oxford Clay. In this shallow drift a block of greywether, 2 ft. × 1 ft. 6 in. × 1 ft., was found in the cutting north-east of Charndon Lodge Farm. There 10 or 15 feet of grey shaly Oxford Clay were to be seen. This contained a few pyritized Ammonites, *Cerithium*, *Leda*, and small examples of *Gryphæa dilatata*. The fossils are such as characterize the middle portion of the Oxford Clay. In Decoy Pond Wood the Oxford Clay was opened to a depth of 15 to 20 feet, and yielded medium-sized specimens of *Gryphæa dilatata*. As we approach the brickyard near the Quainton Road Junction, larger forms of this fossil are found, and at the brickyard itself they occur in great abundance. The intermediate shallow cuttings showed no sections of interest, and beyond an occasional thin gravelly soil, as south-east of Leewood Farm, no Drift was observed between Twyford and Quainton Road.

It should be mentioned that on the railway embankment near Steeple Claydon, a large specimen of *Ammonites Sutherlandiæ*, together with *A. Lamberti* in the same block, was picked up, evidently derived from one of the adjacent cuttings in the Oxford Clay. These and other fossils were identified by Mr. G. Sharman and Mr. E. T. Newton.

II.—The Age of the Morte Slate Fossils.

By Henry Hicks, M.D., F.R.S., Pres. Geol. Soc.

In the last number of the Geological Magazine Dr. J. W. Gregory has undertaken to give an opinion on the whole of the fossils described by me from the Morte Slates in the Quarterly Journal of the Geological Society of May, 1896. He says he has been tempted to do this because someone had "recently read to the Geological Society of Cornwall" a paper in which he "assumes the

Silurian age of the Morte Slates to be so well established that it may be accepted as the basis for future work." Clearly this was too much for Dr. Gregory, and his righteous indignation compelled him at once to endeavour to put a stop to any such assumption. I do not, however, think that I shall have much difficulty in showing that Dr. Gregory's facts and conclusions are unreliable, and show a want of care and discrimination. Whether the fossils turned out to be Silurian or Lower Devonian, would have mattered but little in regard to my views of the stratigraphical position of the Morte Slates; for what I maintained from the first was, that the Morte Slates, instead of being newer than the Ilfracombe beds (Middle Devonian), were older than the latter, and that the apparent upward succession was a deceptive one, and had been produced mainly by thrust faults. If, therefore, Lower Devonian beds occurred in the Morte ridge, the evidence would have been quite as satisfactory in support of these views as if they were Silurian or older. The finding of fossils in the Morte Slates only added strength to my view, since every species hitherto found is unlike any which are known to occur in the Ilfracombe beds on the north side and the Pilton beds on the south, and yet there are numerous fossils in common in the Ilfracombe and the Pilton beds. This at once proves that the Morte beds and those surrounding them must belong to very different geological horizons. I may say in passing that I took pains, knowing the imperfect material with which I had to deal, to obtain the opinions of several specialists in regard to the fossils before I ventured to publish the conclusions at which I had arrived. Now the fossil which has been mainly attacked by Dr. Gregory is *Stricklandinia lirata*,[1] and his remarks on the other fossils show that they are principally made to back up his contention with regard to this form. I will, therefore, confine my remarks at present almost entirely to the evidence adduced by him to show that our *S. lirata* is not that fossil, but *Hipparionyx proximus*, Vanux. His remarks are: "If I had to give [Dr. Hicks' fossil] a name, I should, without much hesitation, call it *Hipparionyx* aff. *proximus*, Vanux., and regard it as also closely allied to *Orthis hipparionyx*, Dav. *non* Hall." This fossil was first described in America from the Oriskany Sandstone, and is considered one of its most characteristic fossils. Now the American geologists class the Oriskany Sandstone in the Silurian, but some European geologists place it at the base of the Devonian. In this country the fossil has been found in beds at

[1] In my description of *Stricklandinia lirata*, from the Morte Slates, I stated that it "approaches most closely in its size and ornamentation the specimens in the Society's Museum and in the Jermyn Street Museum, from the lowest beds of Wenlock age at Marloes Bay, Pembrokeshire." Last year I visited Marloes Bay, and collected several other fossils from these beds, and I am more than ever convinced that the fauna is the same as that I have described from the Morte Slates. A figure of *S. lirata* from Marloes Bay is given on plate xxii in the "Silurian System" (1839) as *Spirifer? liratus*, afterwards altered to *Strick. lirata*. After examining the specimen figured in the "Silurian System," I am satisfied that it belongs to the same species as ours. It is important to note this, as it was the first specimen figured, and it is generally recognized as the type-specimen for the genus *Stricklandinia*.

Looe, Cornwall, which are classed as of Lower Devonian age. So far, therefore, as its stratigraphical position is concerned, it would not be at all surprising if we were to find in so great a thickness of beds as is included under the term Morte Slates, a zone characterized by this fossil. In fact, in the second part of my paper I shall be able to show that Lower Devonian fossils do actually occur in the "Morte Slates" of West Somerset, and that they must be as nearly as possible on the horizon of the Looe Beds. Still, the fossils with which we have now to deal must be treated by themselves, and a somewhat careful analysis of the points referred to by Dr. Gregory will be necessary. As preparatory to this I would ask those who are interested in this question to have open before them page 267 of my paper in the Quart. Journ. Geol. Soc., as the figure given there of *S. lirata* is a reproduction from a photograph, and hence cannot deceive anyone, and pl. xxii, fig. 6, "Silurian System"; next pl. xx of Davidson's Monograph of Silurian Brachiopoda; and then pl. xvii of his Monograph of Devonian Brachiopoda, and also the original figure of *H. proximus* in the "Geology of New York," by Lardner Vanuxem, part iii, 1842, p. 124.

I will take the objections in the order given by Dr. Gregory. He says (GEOL. MAG., p. 61):—"Dr. Hicks lays most stress on the specimens determined as *Stricklandinia lirata*, Sow., of which he has figured four examples, viz., fig. 3, p. 267; and pl. x, figs. 6, 7, and 8. Of the four specimens, that shown on fig. 8 may be left out of account, as it is a smaller and less satisfactory specimen of the form shown in fig. 6, with which it fully agrees; while that drawn on pl. x, fig. 7 has lost the upper part of the shell, so that its family position is indeterminable; the dotted line on the plate which suggests the position of the hinge-line and beak is hypothetical."

In these remarks not a word is said about the characteristic ribbing, which anyone well acquainted with *S. lirata* would at once recognize as so different from that in *H. proximus*. However, as Dr. Gregory has not recognized this and some other points, I need only touch on those which have caught his eye.

He goes on to say that "the two remaining specimens show three characters. . ." Why call a cast and an impression of the same specimen two specimens? Dr. Gregory is not dependent on the published figures, but says that he examined them with care after the meeting; therefore there is no excuse for his not having recognized that it was but one fossil. However, this error evidently helped to increase his subsequent mistakes, for as fig. 6 is a much broken fragment, its normal size does not become apparent from the figure, and it was mainly because of this that I had the impression fig. 3 given also. We have, therefore, only to deal with one fossil, and fig. 6, instead of being only three inches, should be outlined to over four inches in length. Its width also should be considerably increased, and I am satisfied that, in the normal condition of the fossil, from comparison with other specimens found, it would be still wider than is shown in the impression, as, owing to the strong cleavage-line which exposed the fossil, a portion was left

in the other fragment of the slate. However, for present purposes
we will take fig. 3 as it stands, and take the objections in the orde
given by Dr. Gregory :—

“1. The hinge-line is recognizable in the specimen shown in fig. 3
although it is not seen in the figure; the hinge-line is straighte
than in the genus *Stricklandinia*, and agrees rather with *Orthotetes*.
This is a photograph and shows all that is to be seen ; what, then, i
the meaning of saying that it is not seen in the figure? I can se
it clearly, and I presume others can. Davidson says of *S. lirat*
“hinge-line nearly straight, and shorter than the width of the shell,
and so it is here. Compare also for this purpose figs. 3, 4, 10, an
11 on pl. xx, “Silurian Brachiopoda.” It is well known that th
hinge-line in *Orthotetes* is usually *produced*, not rounded at th
cardinal extremities. So much for the hinge-line. Next, as to th
muscular impressions, we are told “a pair of scars are shown on pl.
fig. 6, which Dr. Hicks identifies as muscular impressions. If th
be correct, it tells strongly against the fossil being a *Stricklandin*
for the muscular scars are far too large and wide; they agree w
those of *Orthotetes*, especially with those of the subgenus *Hippariony*
I must once again remind the reader that fig. 6, pl. x is the sa
fossil as fig. 3, p. 267; therefore the size of the scars is to be co
pared with the latter figure, and not with fig. 6: and what is
result? The scars reach to less than one-third of the length, and
Davidson’s figures (10 and 11) of *S. lirata* they are exactly one-th
of the length. In *O. hipparionyx*, on the other hand, as may
seen by examining figs. 8–12 on pl. xvii of Davidson’s monogra
of Devonian fossils, the scars reach in each case to nearly half of
length of the shell, and in fig. 11 to three-fourths of the length,
in the original figure by Vanuxem they also reach to three-four
of the length. It is extraordinary that this fact has been so co
pletely overlooked by Dr. Gregory.

Now as to the width of the scars. As their outer margins
only faintly seen, it is necessary to carry the eye forward from
umbo, which in the cast is raised, and the two pear-shaped sc
will then be recognized on each side of the raised portion. Th
are so much flattened that they can with difficulty be defined fr
the ovarian spaces which surround them, as is commonly the c
in crushed specimens of *S. lirata* (see especially the type-specim
in the Geological Society’s collection, and figured in the “Silur
System”). The scars, however, occupy less than one-third
the width of the shell, again agreeing fairly with those in fig. 11
pl. xx of Davidson’s monograph. The extraordinary difference
this, shown in the original figure of *H. proximus*, where the sc
occupy no less than two-thirds of the width, are strongly rai
and joined centrally, and are most strongly defined on their ou
margins, will at once strike any observer. These facts are a
equally marked in the figures by Davidson of the specimens in
Jermyn Street Museum and elsewhere, obtained from Looe. T
shape of the shell also is far more like *S. lirata* than either *Orthot*
or *O. hipparionyx*. The other fossils to which he specially refers,

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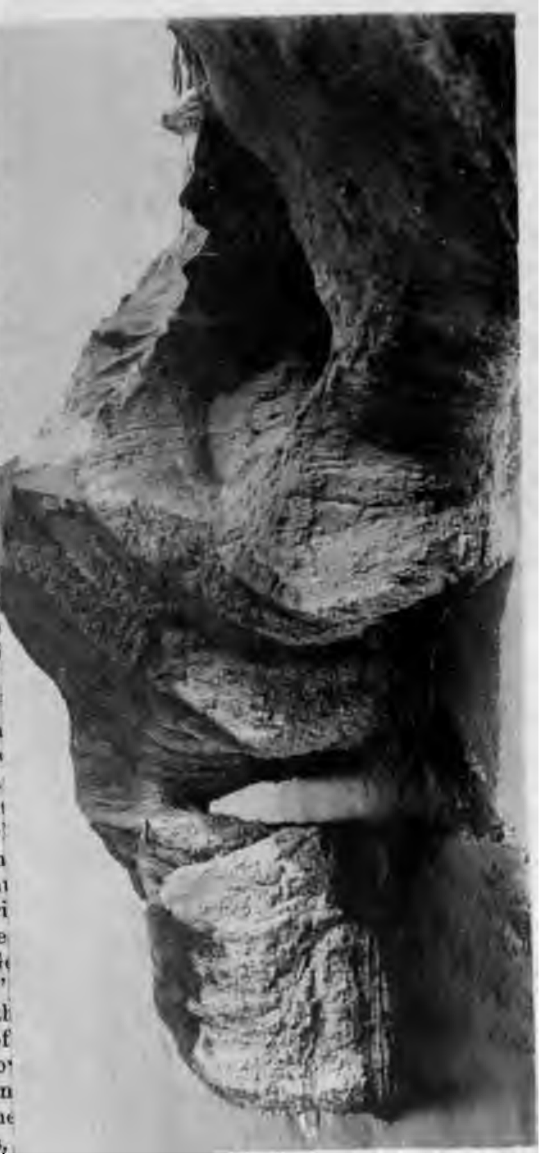
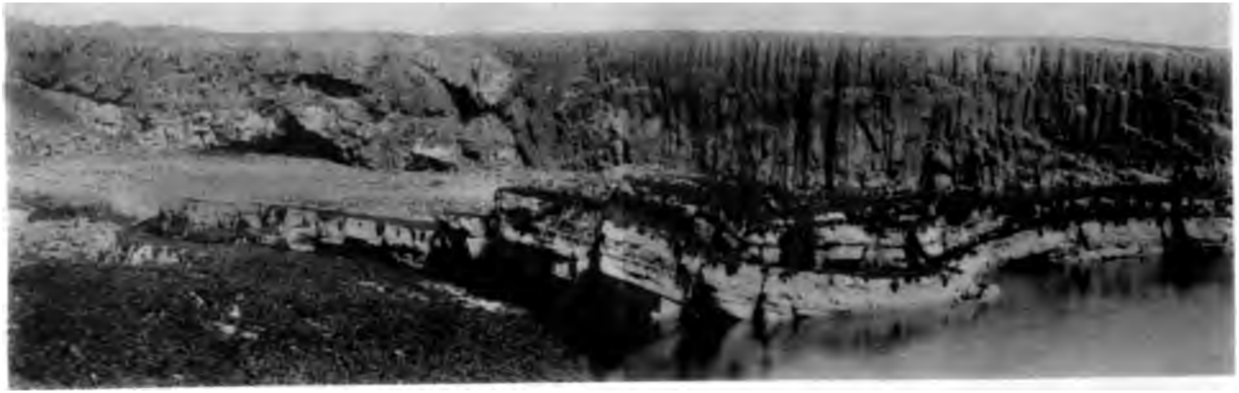


High Stacks, Flamborough Head.

To illustrate Mr. W. W. Watts's paper in the January Number, p. 81, on Geological Photographs.



The Whin Sill at Cullernose, Northumberland.

To illustrate Mr. W. W. Watts's paper in the January Number, p. 31, on Geological Photographs.

From a Photograph by Mr. E. J. Garwood. (see County History of Northumberland. Vol. II., Appendix IV).

Pterinea Mortensis and *Modiolopsis Barricanensis*, do not, in any way, bear out the statements in regard to measurements which he gives, if the distortion by cleavage be taken into account. *P. Mortensis* is greatly reduced in length, and increased in width by pressure, so altering the whole shape of the shell and wings. In its normal condition it would agree well with some *Pterineæ* from the Silurian. Some palæontologists have thought that it might be closely allied to *Avicula Danbyi*, a well-known Silurian form (see figs. of *A. Danbyi* in McCoy's "British Palæozoic Fossils"). The distinction between *Modiolopsis* and *Modiomorpha* rests in the dentition, but unfortunately this cannot be seen in any of the specimens hitherto found. None of the statements made by Dr. Gregory can therefore in any way affect the evidence, stratigraphical and palæontological, which I have brought forward to show that the Morte Slates are the oldest rocks in North Devon.

III.—NOTES ON BRITISH GEOLOGICAL PHOTOGRAPHS.

By W. W. WATTS, M.A., F.G.S.

(*Concluded from the February Number*, p. 62.)

(PLATES III AND IV.)

AS promised last month, we now add a brief note on Plates III and IV of this series, given in this number.

Plate III is one of a beautiful set prepared by Mr. Godfrey Bingley for insertion in the Proceedings of the Yorkshire Geological and Polytechnic Society, from which the plate is borrowed by the kind permission of the editor, the Rev. W. L. Carter. A full description by Mr. G. W. Lamplugh will shortly appear in the "Proceedings" of that Society, and from the manuscript of this I have been permitted to extract the following:—

The cliff to the left is the most easterly point of Flamborough Head; it is formed of the lowermost beds of the flintless Upper Chalk, resting on the uppermost beds of the flinty Middle Chalk, which are seen just above sea-level. In the Chalk a steep-sided valley has been eroded which is now filled with drift. One bank of this valley is to be seen in the exact middle of the picture just above sea-level; the rocky bottom of it runs away to the right, and the drifts in it occupy the whole right-hand half of the photograph. First comes chalk rubble, then boulder-clay, next a seam of dark gravel, seen projecting out of the dark shadow thrown by the sharp ridge to the right, then a light gravel with lumps of chalk, and lastly, extending to the relic of the plateau at the top, Upper Boulder-clay. The characteristic weathering of the drift is shown by the ridges and knife-edges, and the great crater or blow-hole which is such a conspicuous feature in the photograph results from the tapping of the old valley by a small cave driven through its wall; this cave is just out of sight in the shadow of the overhanging cliff in the middle of the picture.

Plate IV is taken from a beautiful panoramic view by Mr. E. J. Garwood, and published by him in the "County History of

Northumberland," edited by Mr. Edward Bateson; it has been lent with the kind permission of the present editor. It shows the Whin Sill breaking across the bedding of sandstones and shales which rest on a bed of limestone; on the left of the picture the Whin has caught up and encloses patches of the shale and sandstone, which have been highly metamorphosed; the sandstone is light-coloured in the photograph, and two patches of it, immersed in the Whin Sill to the left, can be distinguished by their light colour and by the deep shadow they throw over the underlying shales; below the further patch to the left the same sandstone and shale are seen *in situ* below the Whin. The photograph was taken at Cullernose Point on the Northumberland coast.

IV.—NOTE ON AN "OVENSTONE" (TALCOSE-SCHIST) FROM NEAR ZINAL, CANTON VALAIS.

By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., V.P.G.S.

IN the Val d'Anniviers or Einfisch-thal, which joins the Rhone valley at Sierre, the stoves used in warming the houses are often constructed from a stone obtained in the valley. This is so soft that it can be readily cut into shape, but it resists heat remarkably well. According to Gerlach,[1] it is obtained at two or three places, but the only one which I have examined is a quarry some height up on the left bank of the valley, rather above Zinal, to which I was conducted by my friend Mr. J. Eccles, who had noticed it during a former visit to this part of the Alps. It is a short distance from the path to the Arpitetta Alp, a favourite excursion for tourists. The result of our examination seems to be of sufficient interest to justify a brief notice.[2]

The quarry is a small one, and the outcrop, so far as we could see, is limited. The rock occurs among a group of schists to which I have more than once called attention, as possessing definite characters and having a great extension in the Alps. The dominant rock is a calc-mica-schist, of which every variety may be found, from a marble or dolomite, practically pure, to a calcareous or even quartzose mica-schist, the last sometimes becoming a very typical quartz-schist. Associated with this is a green schist, sometimes fine-grained and slaty in aspect, sometimes coarser and distinctly foliated. It is often very difficult to ascertain the relations of this green schist to the calc-mica-schist. Occasionally it can be proved to be intrusive, and this is often suggested by its mode of occurrence; but positive evidence, so far as my experience goes—and I have devoted some time to the subject—is not easily obtained. On the whole, I think that the rock was originally a basalt or dolerite, and is commonly intrusive, generally as a sill, and that it has been converted into a schist by subsequent pressure and mineral change.[1]

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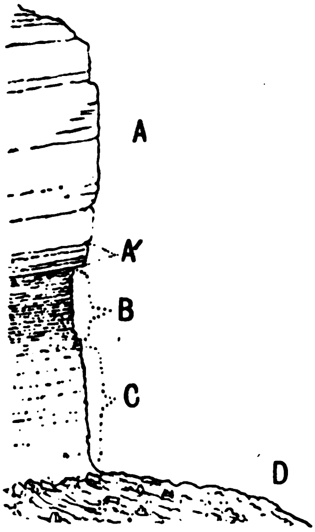
[1] Beitr. zur Geolog. Karte der Schweiz, Lief. ix, pp. 130–1, 142, 173; e.g. near Evolena, L'Allée, and the Moiry Glacier (in another branch of the Val d'Anniviers).

[2] Gerlach, loc. cit. and Lief. xxvii, pp. 87–90, mentions the connection of this "topfstein" with serpentine, grüner schiefer, and grauer schiefer (the calc-mica-schist), but, if I rightly understand him, is not clear as to its origin, or even that of the serpentine.

The annexed diagram gives the section seen in the quarry. A is a compact variety of the green schist (described below), forming a cliff some five or six yards high, A′ indicating a foot or so at the base where the rock is more distinctly fissile; B, a soft flaky rock, rather like a crushed serpentine, the thickness, which slightly varies, being from about 3½ feet to 4 feet; C, the "ovenstone," exposed for about 4 feet; D, a spoil bank. Between B and C there is no sharp line of division, the one passing, though somewhat rapidly, into the other. The condition of B made it practically worthless for purposes of study, so I collected specimens from C only, one being slightly more fissile than the other. The dominant tint in each is a lead-grey inclining to a dull lavender, and sometimes, especially on the smooth faces of the more fissile specimen, to a dull green, as in a much crushed serpentine. In both are greenish-white seams more or less parallel with the foliation. The streak also is white, the hardness rather variable, but under 2. Examination with a lens shows numerous glittering granules of iron-oxide rather irregularly distributed, some of the larger being well-developed octahedra, undoubtedly of magnetite. The slice cut from the more fissile specimen exhibits a rather minute wavy, foliated structure, with more definite cleavage cracks running in the same general direction, the dominant mineral varying in tint from a very pale grey to a light brownish grey. It is traversed by rather irregular streaks, like crushed-up veins, occupied by clear



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[1] Quart. Journ. Geol. Soc., vol. L (1894), p. 283.

granules and very pale-green streaky or flaky spots. The latter mineral is mica-like and pleochroic, being pale yellow-ochre colour with vibrations perpendicular to the cleavage, and dull green parallel with it. The tints with crossed nicols are low, and extinction is either parallel to or at a very small angle with the cleavage. Probably it is a chlorite. The dominant mineral of the slice occurs in minute flakes closely matted, lying more or less in the same direction, which show high polarization tints, pink and greenish blue dominating. It is difficult, owing to their small size, to determine the extinction angle, but that of a few "frayed-out" scales, rather longer than the rest, was not quite straight, but varied up to about 13°.[1] Still, notwithstanding this, I believe the dominant mineral to be talc.[2] There are a few granules of magnetite. In the slice from the other specimen, though apparently cut in the same general direction, the flakes run slightly larger, are more confusedly matted, and the greener mineral occurs in irregularly distributed patches, which do not suggest any connection with veins; in one case it looks as if these might be pseudomorphic. Magnetite is more abundant, both in granules and crystals, and there is a grain or two of pyrite. A little calcite, obviously secondary, and perhaps slightly dolomitic, occurs in one part of the slice. The differences, however, between the two specimens are only varietal.

I am indebted to Miss E. Aston, B.Sc., for an analysis of the more compact of the two specimens of "ovenstone," described above, which she made in the Chemical Laboratory at University College. It is given below (No. I), and by the side I quote that of a talc-schist from Anglesey,[3] which I now think very possibly has been formed from a serpentine (No. II).

	I.	II.
SiO_2	44·94	56·34
Al_2O_3	5·47	8·21
Fe_2O_3	1·75	3·04
Cr_2O_3	trace	—
FeO	3·47	2·00
CaO	8·76	0·52
MgO	25·57	25·43
NiO	2·90	—
MnO	trace	trace
CuO	,,	—
CO_2	1·22	—
H_2O	5·40	2·86
Id. uncombined	0·35	(Na_2O) 0·79
	99·83	99·19
S. G.	2·90	2·82

Miss Aston remarked that specimens of the rock (No. I) proved not to be very uniform, some containing more CO_2 than others. The amount of H_2O and NiO also varied, the latter being in a second sample only 0·5, and in a third not more than 0·25 per cent. The first variation is no doubt due to the fact that the carbonate occurs in small veins. That of the NiO accords with what was observed in the Riffelhorn serpentine, but here I fail to discover awaruite, and conclude that all the nickel must be present as a silicate.[1] So far as one can judge from rough calculations, the specimen analyzed above might consist of quantities, approximately equal, of talc, tremolite, and a chlorite.

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[1] Cf. description of serpentine from the Gornergrat, Quart. Journ. Geol. Soc., vol. lii (1896), p. 452.

[2] It may be an optical anomaly due to strain, or, as suggested by Rosenbusch, to an admixture with actinolite, almost identical in general aspect. I obtain the results in both slices.

[3] Quart. Journ. Geol. Soc., vol. xxxvii (1881), pp. 44–5.

Through the kindness of Professor W. Ramsay, F.R.S., I have had the opportunity of examining a specimen of noumeite[2] from New Caledonia, a mineral to which a passing reference was made in the paper by Miss Aston and myself on the Riffelhorn serpentine. The hand-specimen has a somewhat "waxy" aspect and lustre; in colour is a rather variable emerald-green,[3] mottled with spots, diverse in size and quantity, of a dark, somewhat purplish tint, giving the mass a slightly brecciated aspect. This last becomes more distinct on microscopic examination. The apparent fragments are "flaky" in outline, and differ much in size, the larger being darkened by the presence of a brownish dust, but all are more distinctly yellow in colour than the ground-mass. They consist of a fibrous or flake-like mineral, which exhibits a very faint pleochroism and bright polarization tints. The small size and entanglement of the flakes make it difficult to ascertain their extinction angle, but if not straight this angle is very small. Possibly more than one mineral is really present. The ground-mass in which these patches and spots occur is fairly uniform in aspect, just tinged with a greenish yellow, and now and then traversed by lighter-coloured, more compact-looking veins. With crossed nicols it appears as a dark ground speckled with whitish granules or flakelets. Probably, however, it consists of a densely matted mass of doubly refracting minerals, allied to serpentine. The aspect of the whole suggests that fragments of a badly preserved, perhaps rather exceptional serpentine, are imbedded in a kind of steatite. Analyses and a description of noumeite are given in Dana's "Mineralogy,"[4] where it is counted, with garnierite, as varieties of genthite. All three are described as apple-green minerals, varying from light to dark, rather soft, and non-crystalline. Professor Liversidge, who has made special studies of both,[5] states that garnierite differs mainly from noumeite in being much less common, lighter in colour, adhering to the tongue, and falling to pieces in water. Microscopic examination of the above-named specimen makes it fairly certain that the noumeite is in a crypto-crystalline condition, like chalcedony, steatite, etc.[1] Both Dana and La Croix quote a number of analyses, which show that noumeite must be a very variable silicate.[2] Professor Liversidge states that these nickel silicates occur as veins in or incrustations on a brownish or plum-coloured serpentine. There is, therefore, a considerable probability that a nickel mineral of the genthite group may enter into the composition of some of these Alpine serpentines. Generally, no doubt, the amount is small, but I have occasionally noticed a rather peculiar mottling of a rich apple-green material (which now reminds me of the noumeite) and of a purplish one in the Alpine serpentines (recalling the plum-coloured tint just mentioned). Without forming any very definite opinion, I had been disposed to attribute this appearance to pressure, but it now occurs to me that it may be due to the presence of hydrous nickel silicates.

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[1] At Ayer, a hamlet about an hour's walk down the valley, are old nickel-mines, but as I did not anticipate this mineral turning up here, I did not visit them.

[2] Named from Noumea, capital of New Caledonia; described by Professor Liversidge, Proc. Roy. Soc. N.S.W. 1875, p. 75; Journal, 1881, p. 227.

[3] This part is not unlike chrysocolla, but the colour is rather brighter.

[4] Ed. 1892.

[5] Proc. Roy. Soc. N.S.W., ut suprà.

It is well known that serpentine is by no means rare in the Alps. The rock is usually associated with the above-named group of schists, but occurs, though rarely, in the gneisses. Its most common associate is the green-schist. As I have already stated, there are two principal varieties, one containing bastite, the other augite (though sometimes both minerals are present), and the rock is always, or almost always, a dark green in colour. Sometimes the serpentine seems normal in character, but it is often more or less affected by pressure, passing from a stage where it breaks into irregular or lenticular "slickensided" flakes, to that where it is fissile, like a slate. Occasionally we can find distinct evidence that it is an intrusive rock; more often this has to be inferred from the way in which the masses occur, and their outline on a map. The outcrops in the Zinal district are few and small, the largest known to me being on a lofty ridge called the Crête de Million.[3] Here it is clearly intrusive in the green-schist, a mass of which it includes, together with another of a whitish quartzose rock. Some of this serpentine exhibits the effects of pressure, but parts of it have escaped very well. It is the augitic variety. I have examined specimens representing the two extremes of structure. As they differ little from other Alpine serpentines of which accounts have been published,[4] it is needless to enter into minute descriptive details, and I will notice them only so far as they throw light on the "topfstein."

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[1] See also La Croix, "Mineralogie de la France et ses Colonies," vol. i, p. 438. He speaks of noumeite as either crypto-crystalline or amorphous.

[2] To speak only of the nickel-oxide, that varies generally from 22·0 to just over 45·0; but in one case 14·6, in another 10·2, and in a third only 2·32. C. A. Münster, quoted in Min. Mag., vol. x, p. 39, says that he has found nickel-oxide replacing magnesia in olivine, serpentine, steatite, etc. Professor Liversidge suggests that the formula of noumeite may be $2\,MgO\;3\,SiO_2\;2\,H_2O$, where some of the magnesium is replaced by nickel.

[3] I am indebted for notes and specimens of this mass to my friend, Mr. J. Eccles, F.G.S., but I had a remarkably good view of it at a distance of about half a mile, during the ascent of a neighbouring peak. As I know him to be one of the most accurate of observers, and the glen leading to the base of the Crête is very stony and uninteresting, I absolved myself from undertaking a tiresome walk.

[4] By various authors, myself included.

The specimen which shows considerable signs of crushing has a foliated structure somewhat resembling the above described, but rather less conspicuous. It also contains a greenish mineral, which occurs both in irregular streaks and in mottled patches, down to mere specks; this, however, has a weaker pleochroism, but high polarization tints and straight extinction, and is no doubt antigorite. There is some iron-oxide, but the specimen differs little from other crushed Alpine serpentines which I have already described.[1] The specimen of massive aspect is, macroscopically, a dark-green rock, like the last, but is mottled with spots of paler and greyer green. The ground-mass, on microscopic examination, consists of a minute speckled mass of ordinary serpentine, in which flakelets of antigorite occur like an irregular stitching. The lighter spots prove to be a slightly brown augite, often "dusty" in aspect, owing to a minute granular structure. These occasionally enclose grains of serpentine, indicating a slight "lustre-mottling." The edges of the augite are sometimes very slightly frayed out, but there is nothing to connect it with the formation of antigorite. Magnetite is fairly abundant, in grains, occasionally showing some faces of a crystal and in granules, both with a clustered habit. This rock evidently belongs to the group of Alpine serpentines which has been derived from augite-peridotites.[2]

The green-schist, though also affected by pressure, is a very different rock from the "ovenstone." Macroscopic examination alone shows it to be a very characteristic, rather compact member of the green-schist group (Grüner Schiefer). Under the microscope it exhibits a slightly banded, foliated structure. There are two predominant minerals: one is a chlorite, which occurs both in separate flakelets and in streaky aggregated flakes, with pleochroism from pale ochre to dullish green, and oblique extinction, the angle in some cases being quite 25°; the other, which occurs in grains and granules, with rather irregular outlines, suggestive of a clastic (no doubt cataclastic) origin, is water-clear, with rather high polarization tints, one or two grains being twinned apparently on the Carlsbad type. It encloses often minute flakes of chlorite and almost colourless belonites (? actinolite). Probably it is a secondary felspar.[3] A fair amount of calcite is found, and granules of a slightly yellow tinge are rather numerous, especially with the chlorite. I think most of them are epidote, though sphene also may be present. Except for one or two scales of hematite, iron-oxides are absent. That the rock is one of the Alpine "green-schist" group, is beyond all doubt.[4]

A study of this "ovenstone" confirms the view which I have already expressed that a talcose schist may be only a further stage in the alteration of a much crushed serpentine, or the third remove, at least, from a peridotite[1]; and the presence of nickel as a silicate suggests that in all probability minerals allied to genthite not unfrequently occur in the Alpine serpentines[2]—and, it may be, in others. Comparison of the ovenstone and of the varieties of serpentine from this and other parts of the Alps with the ordinary green-schist, prove them and it to be such distinct rocks that they must be independent in origin.

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[1] Some of it shows strain phenomena, indicating the action of a pressure subsequent to that which has produced the general structure of the rock.

[2] Loc. cit., p. 452.

[3] This is the mineral which in some earlier papers I suggested might be a variety of kyanite. It is a frequent constituent of these green-schists.

[4] In these rocks, as I have already described, the green mineral is sometimes a prismatic or acicular hornblende, sometimes chlorite, and both minerals may be present. The "chlorite schist" of the Start and Bolt Head district in South Devon is a rock of similar character to these Alpine green-schists.

V.—*APIOCRINUS RECUBARIENSIS*, CREMA, FROM THE MUSCHELKALK, IS A PRIMITIVE *MILLERICRINUS*.

By F. A. Bather, M.A.,
Assistant in the British Museum (Natural History).

LAST autumn Dr. Camillo Crema, of Turin, civil engineer, favoured me with a reprint of "Addizioni agli Echinodermi del Muschelkalk di Recoaro," a paper published on October 4, 1896, in Atti del R. Ist. Veneto, ser. 7, vol. vii, pp. 854–61, with plate ii. The Echinoderms described are in the Royal Geological Museum of Turin, and were found in the Lower Muschelkalk near Rovegliana, east of Recoaro, in the Vicentin Alps; a section of the Trias in this district will be found in K. W. von Gümbel's "Geologie von Bayern," Dritte Lieferung, p. 679, 1886. Two species are added, under the names of "*Aspidura italica*, n.sp." and "*Apiocrinus recubariensis*, n.sp." Two crowns of *Dadocrinus gracilis*, though previously known from this horizon and locality, are also figured on account of their good state of preservation.

With regard to the "*Apiocrinus*," Dr. Crema, in his paper, does not "absolutely exclude the chance that it may turn out to be a *Millericrinus*," since the differences between *Apiocrinus* and *Millericrinus* are, in his opinion, of such a nature that they cannot be distinguished in this specimen. "However this may be," the determination assumes importance from the fact that "neither of these two genera has hitherto been observed in terranes anterior to the Lias." Dr. Crema's figure and description, however, did not satisfy me as to the correctness of his generic determination, so that I at once communicated my doubts to him, and asked to be favoured with a cast of the fossil. For reply I received the loan of the unique specimen itself, an act of courtesy for which my warmest thanks are due, not only to Dr. Crema, but to Professor C. F. Parona, Director of the Geological Museum of Turin.

The minute crinoid showed that the description and figure of Dr. Crema were as accurate as the state of the fossil permitted, and that his inferences were very natural ones if nothing more. The additional details now submitted, and the slightly different conclusions of the present paper, have been rendered possible by the further development of the specimen, a task of many days.

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[1] GEOL. MAG., December, 1890, p. 540.

[2] I do not see much hope of identifying them under the microscope, for the noumeite shows no definite characters.

The specimen (Fig. 1) consists of—

Portion of stem	8·0 mm. long
Cup	2·0 mm. high
Portion of arms	3·0 mm. long
Pinnules extending beyond arms	1·5 mm.
Total absolute length (appearing about 1 mm. less owing to curvature)	14·5 mm.

There is also a portion of an arm, obviously belonging to this specimen, bent downwards along its left side. Other arm-fragments, probably derived from this individual, are scattered over the small slab of stone (5 × 3·5 cm.) on which it lies. This also contains a crenelate columnal, almost certainly belonging to *Dadocrinus gracilis*.

The Cup (Fig. 2) consists of two circlets—basals and radials; doubtless five in each circlet.

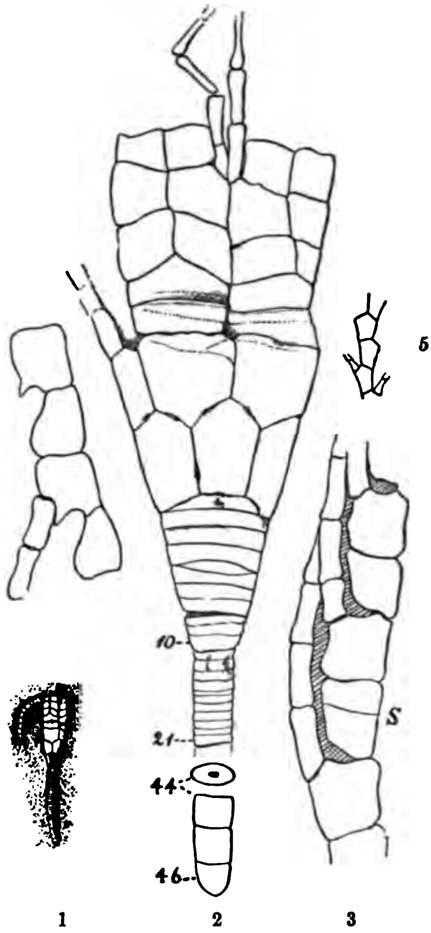
Of the Basals three are visible in whole or part. That in the middle, which is clearly seen, is a pentagon, with even horizontal base. Height 1·1 mm.; proportion of height to greatest width almost 3 : 2. The other basals are of similar size and shape, except that their bases appear to slope downwards away from the middle one.

Of the Radials, three are visible in whole or part. That in the middle, which is clearly seen, is a pentagon with the upper angles slightly truncate or rounded, and with the distal margin slightly curved by a narrow median depression and two broader depressions on either side. A distal margin with similar curvature, more emphasized, is figured for *Rhizocrinus Rawsoni*, by P. H. Carpenter ("Challenger Report, Stalked Crinoids," pl. liii, fig. 8). Height about 1·2 mm.; width about 1·3 mm. The curvature necessarily foreshortens the width in the figure. The other radials appear to be of much the same size and shape. This middle radial is peculiar in the presence of a fine furrow running across its upper third and trending downwards from left to right; this may represent an abnormal fission of the radial, for such does occasionally occur, and may in some cases be regarded by a speculative mind as a reversion to the horizontal bisection of certain radials characterizing so many Monocyclic Inadunate Crinoids. The radial to the right exhibits a slight furrow parallel to its distal margin.

The inter-basal and inter-radial sutures are fairly straight; but the basi-radial sutures are a little flexuous, and show appearances of a slight median depression in each.

Portions of three Arms are visible, directly attached to the cup (Fig. 2).

Of these, that on the left consists only of portions of two or three brachials imperfectly seen from the side, and needs mention only because of its position, which suggests, if it does not prove, that during life the arms could be bent outwards from their union with the cup itself, at an angle slightly exceeding the slope of the sides of the cup. The proximal brachials of the middle and left-hand arms are, on the contrary, bent inwards, so as to lie at as great an angle in the other direction. These facts, therefore, indicate that the union between radials and first primibrachs was a true articulation, permitting motion through an angle of at least 45°. The sinuous distal margin of the radial also suggests that the union was articular, and certainly not by close suture.



Millericrinus recubariensis, Crema, sp.

Fig. 1. The type-specimen, × 2.
,, 2. The cup, arms, and portions of stem of the same, × 10. The proximal surface of the 44th columnal is drawn.
,, 3. Portion of an arm-fragment lying near the lower edge of the slab on which is the type-specimen, × 12. *s* = syzygy.
,, 4. Portion of the arm-fragment that is bent downward on the left side of the type-specimen and probably belongs to it, × 12. This is drawn with the distal end downwards, as in Fig. 1.
,, 5. Portion of fragment from the distal end of an arm, × 12.

A further point of importance in this connection is the separation of the arms from one another by a space beginning, as above intimated, on the shoulders of the radials; while the absence of preserved inter-brachial plates in this space suggests that it was filled, if at all, only by a flexible extension of the tegmen, in which such plates as may have existed can only have been minute and loosely united. In short, there was nothing to impede the perfectly free movement of the arms which we have already inferred.

The Primibrachs (IBr) are two. Their width is slightly less than that of the radial, but they expand a little upwards. IBr$_1$ has a height of little less than half its own width. Conspicuous on IBr$_1$ of the middle arm is a clear, fine groove slanting downwards from the left upper angle to a little below the middle of the right side. A somewhat similar marking is less evident on IBr$_1$ of the arm on the right. This line may indicate the compound origin of IBr$_1$, and may even be caused by a syzygial suture, such as occurs at the same level in *Calamocrinus Diomedeæ*; but it is hardly definite enough to permit one to speak of three primibrachs. Each IBr$_1$ further shows a faint groove close to, and parallel with, its distal margin. IBr$_2$, the axillare (IAx), is about ·75 mm. high and 1·4 mm. wide. In the middle and right-hand arms it lies at an angle to IBr$_1$, forcibly suggesting that here also the union was articular.

Of the Secundibrachs (IIBr), three are preserved in each distichal series of the middle and right-hand arms. IIBr$_1$ and IIBr$_2$ are subquadrate, about as high as wide, expanding upwards slightly. IIBr$_1$ bears no pinnule. In the right-hand branch of the middle arm and the left-hand branch of the right-hand arm, IIBr$_2$ bears a pinnule at its outer upper corner. This was probably also the case with IIBr$_2$ in the other branches. IIBr$_3$ is narrower than the preceding, and seems to have borne no pinnule, but was most probably joined to IIBr$_4$ by a syzygy—a fact that would explain the snapping off of all the branches at this level.

On the suture between IIBr$_2$ and IIBr$_3$ in the left-hand branch of the right-hand arm, is seen a small upward bend, which represents the end of the fulcral ridge, and indicates that, as one would expect, this union was a perfect articulation.

The first Pinnules (Fig. 2), like those in more distal regions of the arm (Figs. 3 and 4), are thin, and composed of ossicles with a length three or four times their own width, and with slightly hollowed sides. Similar pinnules are possessed by the adult *Antedon longipinna*, but seem to be common to all young Antedons, and perhaps to the young of most pinnulate crinoids.

There is no proof, nor is it at all probable, that the arms branched again. We may therefore consider the adjacent arm-fragment (Fig. 1), and the other fragments alluded to, as composed of secundibrachs, and may describe them here.

The adjacent arm-fragment (Fig. 1) consists of ten brachials, disposed in a curve with a chord of 3·25 mm. Five of these seem to show traces of pinnules, and the alternating five doubtless bore pinnules on the other side, so that in this portion of the arm there were no syzygies. If we assume, as seems legitimate, that this arm-fragment represents the immediate continuation of the left-hand branch of the middle arm, then the pinnules of this arm will have followed in regular alternation on all IIBr down to $IIBr_{18}$, except the first and third. A portion of this arm-fragment is enlarged in Fig. 4. It shows clearly the origin of the pinnules, and the spine-like process, presumably the end of a narrow ridge separating the pinnule-facet from an embayed curve just ventrad of the distal margin of the brachial. Such an appearance is not exhibited by recent specimens of *Calamocrinus*, *Pentacrinus*, or *Metacrinus*, but is fairly common in ten-armed species of *Antedon*, especially *A. longipinna*, *A. hirsuta*, *A. lævis*, of the *Tenella*-group; also in *A. echinata* [illegible]s, of the *Basicurva*-group. It occurs, as here, neither in the immediately proximal, nor in the more distal, regions of the arm, but is most obvious in the second quarter of the distichal series, or thereabouts.

A more distal portion of an arm, lying separate on the slab, and probably from about the third quarter of the arm, is represented in Fig. 3. Here the ridge bounding the pinnule-facet is no longer perceptible, while the embayed curve can hardly be distinguished from the general curve of the distal articular surface. Two of the brachials here shown are united by a syzygy (*s*), and form a syzygial pair with a total length very slightly more than that of an ordinary brachial from the same region.

A small fragment, most probably belonging to the distal region of an arm of this specimen, is depicted in Fig. 5. In this the brachials, as usual in distal arm-tracts, have almost the aspect of axillaries, though each pinnule, rapidly becoming more thin than the main arm-branch, is easily distinguished from it.

Of the STEM (Figs. 1 and 2), 46 columnals are preserved. As seen in the normal position of the specimen, they are of rounded appearance, with neither angles nor depressions, nor any trace of cirri or cirrus-facets. The proximal 10 columnals gradually increase in width towards the cup, forming a cone, the sides of which are continuous with those of the cup, the angle being, as Dr. Crema says about 20°. Immediately below the cone the columnals appear compressed, so that the stem seems constricted to ·25 mm.; but they immediately resume the normal width of about ·5 mm., which continues to the distal end of the preserved fragment.

The proximal columnal is thus described by Dr. Crema: "La placca centro-dorsale, relativamente sottile, pressenta ben sviluppate le cinque creste salienti." By "placca centro-dorsale" Dr. Crema means, as so many palæontologists erroneously mean, the columnal which De Loriol has named "article basal." This phrase denotes nothing more than a proximal columnal, permanent in size and position, often larger than the succeeding columnals, and usually marked on its proximal surface by five depressions for the five basals, between which are five distinct ridges. In ascribing such a columnal to the present specimen, Dr. Crema must have jumped too rashly from a part to the whole. It was, and even now remains, impossible for anyone to see "le cinque creste salienti," even if they existed. But they do not exist: the proximal columnal is now shown to be incomplete; it only occupies a portion of the basal surface of the cup, and some of the basals rest, in whole or part, on the columnal next following.

Between the fourth and fifth columnals is an intercalated ossicle, which may be a fresh columnal in the early stages of development. It appears, however, as though growth of the stem, by the intercalation of columnals, was effected chiefly below the level of the cone; the 15th and 20th columnals of this stem are such freshly formed ossicles.

In the cone and proximal region of the stem, all the columnals are relatively low; but towards the distal end of the portion preserved they increase in height, so that the 45th is rather higher than wide.

The columnals are stated by Dr. Crema to be "coperti nelle faccie articolari da fine strie raggiate." What articular surface was seen by Dr. Crema I cannot make out from the specimen; nor does it appear to me that the suture-lines, as seen in the normal position of the specimen, yield any evidence for the presence of radiating striæ. As a matter of fact the only articular surface that I was able to expose, namely the proximal surface of the 44th columnal (see Fig. 2), appeared under the microscope perfectly smooth. It should further be noted that it was elliptical in section, perhaps owing to compression after death, so that the actual diameter of the stem would have been about ·37 mm., instead of ·5 as it appears.

The 46th columnal, the last preserved, is rounded at its distal end. This may be due to the weathering of the fossil, or may indicate that the animal freed itself from its attachment while living, as in the classical instance of *Millericrinus Pratti*, so well described by P. H. Carpenter (Quart. Journ. Geol. Soc., vol. xxxviii, p. 29, Feb. 1882).

We have now to consider to what genus this crinoid belongs.

The genera as yet recorded from the Muschelkalk, and indeed from the Trias generally, are *Encrinus*, *Holocrinus*, *Dadocrinus*, and some columnals doubtfully referred to *Pentacrinus*. The fragments to which other names have been assigned by various authors are probably all to be referred to one or other of these genera, except when they are not crinoids at all. Examination of the type-specimen (Brit. Mus. 75,861) of *Flabellocrinus cassianus*, Klipstein ("Beitr. z. geol. Kenntniss d. östl. Alpen," p. 277; 1845), proves it to be an *Encrinus* not far removed from *E. cassianus*, Laube (1865). *Traumatocrinus*, Wöhrmann ("Die Fauna d. sog. Cardita- und Raibler-Schichten, u.s.w.," Jahrb. geol. Reichsanst. Wien, xxxix, p. 190; 1889), which has for type *Porocrinus caudex*, Dittmar ("Zur Fauna d. Hallstädter Kalke, u.s.w.," Geognost.-palaeont. Beitr. I, Heft ii*b*, p. 394; 1866: non *Porocrinus*, E. Billings), is based only on columnals which do not differ greatly from some of *Encrinus*. I am indebted to Dr. Emil Böse, in Carlsruhe, for the references to this little-known form, which, in any case, has nothing to do with the present species. From *Encrinus* this differs in its uniserial arms, its narrow conical calyx, and minor characters. From *Holocrinus* and *Pentacrinus* it differs, if in nothing else, in the total absence of cirri. It might be regarded as a young *Dadocrinus* were it not for the absence of all expansion in the radial circlet, the conical enlargement of the proximal columnals, and perhaps the tenuity of the pinnules, especially the proximal one, which in *Dadocrinus* is relatively large, retaining more than the other pinnules a memory of the time when it was a full-grown arm-branch. The position of brachial syzygies, however, accords fairly with what we know of *Dadocrinus*, except for their occasional occurrence in the more distal regions of the arm.

Turning to pre-Triassic Inadunate crinoids, there is no reason to suppose that they contain a congener of our fossil: the apparent regularity of the cup, the absence of any anal plates or anal tube (inferred from the space occupied by the radials in the portion exposed and from the absence of any remains of an anal extension of the tegmen), and the non-appearance of infrabasals, all disincline one to place it with the Palæozoic Inadunata.

We look, therefore, to the Mesozoic crinoids, and among them we must, I think, confine ourselves to the pseudo-monocyclic descendants of the Inadunata. There is no reason for instituting a comparison with such totally different forms as *Bourgueticrinus*, *Rhizocrinus*, *Eugeniacrinus*, or their allies. From the Pentacrinidæ this crinoid is removed by the absence of cirri, and we are thus restricted to the Apiocrinidæ.

The family Apiocrinidæ is that to which Dr. Crema has referred his new species, but his reference of it to *Apiocrinus* is opposed by the details now manifest. It is clear, as shown above, that the primibrachs of each ray were not united by close suture either to the radials, or to each other, or to the primibrachs of the adjacent rays; but these are, as Dr. Crema fully recognizes, the chief characters distinguishing *Apiocrinus* and *Guettardicrinus* from *Millericrinus*. Not that this species is a very typical *Millericrinus* either. The proximal cone of the stem undoubtedly suggests the Apiocrinidæ, but the proximal columnal itself has neither the full development nor the regular shape, with "five salient crests," that would entitle it to De Loriol's name, "article basal." It is true that the proximal columnal of Apiocrinidæ may abnormally be imperfect, as in *Millericrinus Pratti* (see P. H. Carpenter, Quart. Journ. Geol. Soc., vol. xxxviii, p. 33); but that does not make the present structure any evidence in favour of Apiocrinid affinities. The columnals below the cone are, as a rule, in Apiocrinidæ of less height than those of the cone; but here they are higher. The basals are higher in proportion to their own width, and to the height of the radials, than they are in any *Millericrinus* earlier than the globose and peculiar species of the Sequanian, such as *M. fleuriausianus*. In fact, the height of the radials also, and the height of the cup generally, are not quite in keeping with *Millericrinus*, which, like all Apiocrinidæ, usually has the plates of its cup wider than high. According to De Loriol ("Paleontologie Française, Terrain Jurassique, Crinoides," p. 319), the first and second primibrachs of *Millericrinus* are united by synostosis; here the evidence seems to point to a more flexible union. Moreover, one may adduce the apparent compound nature of IBr_1 as a condition that has never been found in any Apiocrinid, except the very different *Calamocrinus* of modern times. The secundibrachs too, with their delicate pinnules, have not the wide and thickset appearance so characteristic of nearly all Apiocrinid arms known to us.

It must, of course, be remembered that some of these features are those of youth: such especially are the relatively large basals and the fine pinnules. Nevertheless, all cannot be thus explained away, and it must be admitted that the species is distinct, not only from other known species of *Millericrinus*, but from the general type of the genus and of the family Apiocrinidæ. Indeed, apart from the proximal cone of the stem, perhaps even with that encumbrance, there seems small reason why this form might not just as well be placed along with *Dadocrinus*, either in the Encrinidæ, where *Dadocrinus* is placed at present, or in some fresh systematic pigeon-hole.

The facts, then, seem to lead us to the conclusion that the *Apiocrinus recubariensis* of Crema is a form intermediate between the Encrinidæ and Apiocrinidæ. Its nearest allies are, on the one hand, the Encrinid that other considerations have already brought us to regard as near the ancestor of both Pentacrinidæ and Apiocrinidæ, as shown in my paper "*Uintacrinus*: a Morphological Study" (Proc. Zool. Soc. 1895–6, pp. 974–1004), namely *Dadocrinus*; on the other hand, the genus that is clearly the least specialized Apiocrinid, namely *Millericrinus*. Considering the obviously immature characters of the specimen before us, it would be unwise to make it bear the weight of a distinct generic name. I shall therefore, somewhat arbitrarily, consider the proximal cone of its stem as entitling it to association with *Millericrinus* rather than with *Dadocrinus*, and so leave with Dr. Crema the honour of having been the first to make known the presence of an Apiocrinid in strata below the Lias, and of a complete *Millericrinus* in beds older than the Inferior Oolite.

It will now, I hope, be understood that *Millericrinus recubariensis* is a form of singular interest, and that others besides myself may be grateful to Dr. Crema and Professor Parona for having sent it over land and sea to be described and figured in greater detail.

VI.—On the Erratic Boulders and Foreign Stones in the Drift Deposits of Eastern England, and their Lessons.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

HAVING already discussed the contents, the distribution, and general facies of the widely-spread deposits of Eastern England, which together make up the series classed as Glacial beds, namely, the Post-Tertiary clays, sands, and gravels which have been supposed to attest an Ice period; and also set out the reasons why, to myself and perhaps to others, the attribution of the surface-beds to such an origin is irrational and impossible (irrational because the theory involves our overlooking nearly every feature of these beds in order that we may explain one or two difficulties in them; and impossible because, so far as ice can be judged by the tests of ordinary mechanics, it is incapable of performing the kind of work which has been demanded of it by those who explain these beds by the intervention of ice in any form)—I will now turn to one element in the beds which still remains to be examined, namely, the foreign stones. These, as I have said before, constitute barely a hundredth part of the whole, and yet they have dominated the position so much that it is chiefly on their account that geology has been burdened with perhaps the most stupendous appeal to the imagination which it has had to carry in its long career.

Before I turn to the special features which mark these foreign stones, I will say something of certain characteristics which they share with all the boulders and masses of stone in these beds, and which seem to put an appeal to ice for their explanation out of court.

If I traverse in part some elementary ground, it is because elementary mechanics are so constantly ignored by the Glacialists. By ice I mean, of course, what every-day people mean by ice—the ice we can examine in our laboratories, or in glaciers, or in those sheets which occupy some upland districts of Switzerland, Norway, or Greenland. I do not mean the ice that exists in Mars or in Saturn, or in the imagination of that transcendental school of philosophers who call themselves Glacial Geologists. About this latter kind of ice I know nothing, and I profess to know nothing. Nay, more, when I am gravely told that the ice in the ice-sheets of former days was something so different to the ice we can experiment upon, that it is no use appealing to the latter (which is the last ditch in which the Glacialist plants himself), I feel that the question at that stage has become one of poetry, and that the Poet Laureate, and not a simple reader of the GEOLOGICAL MAGAZINE, must be the judge. The ice I propose to discuss is perfectly mundane—is frozen water and nothing more.

A glacier, such as we know it, is a mass of ice which moves to some extent *en masse*, so long as its bed has a sufficient slope to give it impetus, but in the main moves as a plastic body by the rolling of one of its layers over another.

When there are overhanging or projecting rocks above its surface, these get disintegrated by the action of frost and weather, and the result is that angular masses of varying size roll down upon the back of the glacier. If the slope of the glacier's bed be slight and continuous, the glacier will be a continuous river of ice, without cracks and crevasses, and these angular stones will be carried by the glacier on its back as far as the ice continues to move, retaining their angularity throughout, and remaining angular at the finish.

If the slope of the bed of the glacier be neither continuous nor even, but be in some places at a sharp angle and in others at an obtuse one, or be marked by hummocks, the strain upon the ice at certain points will cause it to crack and gape and to form crevasses. These crevasses will remain open so long as the strain exists, but when the glacier gets on to even ground they will necessarily close up again. We cannot understand how crevasses can be formed, or remain open long, where ice is moving over a level or nearly level surface.

The result of the formation of these crevasses if the ice be not very thick is that some of the stones which have fallen on the glacier's back will tumble down fissures and reach the glacier's bed. The rest which escape this and similar catastrophes will continue their journey, as before, to the glacier's foot. This process has been often observed, and is, of course, an elementary experience in the Alps. It is usually argued by those who believe in ice-sheets several miles high that exactly the same process would take place with them. How this is to be brought about I fail to see. A great hummock or lump in a glacier's bed may cause a sufficient strain to crack and open out a crevasse in ice two or three hundred yards thick; but what possible lump or hummock is to cause sufficient tension in a mass of ice even a mile thick so as to cause it to crack and gape, is beyond my prosaic mind to conceive. This stupendous mechanical difficulty is not met at all by the Glacialists, but is quite ignored by them.

The fact is, that even in the Alps, where the ice is thick, a great many of the crevasses do not reach the bottom of the glaciers at all, and the stones which fall into them are arrested midway, forming the so-called englacial boulders about which so much astonishing matter has been written, and to which I shall revert presently. What I now wish to emphasize is, that where no rocks project above the surface of the ice the glacier will carry no stones. This is beautifully proved by the case of Greenland. In those parts of Greenland where there are no *Nunatakkar*, the Danish observers have noticed that there are no moraines, and it would seem to follow that when, as is postulated by the extreme Glacialists, the whole of a country was buried deep in ice and there were no projecting rocks above its surface, there could be no boulders on its back.

I cannot conceive how it is possible to understand (as a mere piece of mechanics) how crevasses could be formed at all in those stupendous ice-sheets which are continually postulated, and how, therefore, any stones could under any circumstances reach the ice-back or the ice-bed in such cases. The ice-sheets would be as barren of stones as the glaciers of Central Greenland are of moraines. Let that pass, however.

Following in the footsteps of my friend, Mr. Oldham, I have tried to show in my "Glacial Nightmare" that ice cannot be moved *en masse* along a level surface by any push from behind it for more than about seven miles without crushing, and in order to move it in this way the thrust must be enormous when the ice is at all thick—so enormous that I have never been able to understand how and by what process the thrust can be transmitted along the mass when once we leave the steep mountain valleys where glaciers are generated. Of course, to the people who deal with the kind of ice that Alice found in Wonderland everything is possible, and nothing needs proving; but to most of us it is a condition precedent to our assent to the postulate that an ice-sheet several miles thick can be moved *en masse* along a level surface, that some sufficiently potent impetus should be pointed out.

The second way in which ice can move is by virtue of its plastic nature. This I have discussed at great length in my work already cited. There can be no doubt, as is shown by evidence of all kinds, that the principal movement of a glacier is of this kind. There can be just as little doubt that this movement must be slow under any circumstances, and in a body so little plastic as ice that it requires a very considerable slope in the surface of the glacier to initiate it. Thirdly—and this is most important—this kind of movement is largely confined to the surface layers of the glacier, and, except on very steep slopes, there is hardly any movement at all in the lower layers. Ice, in fact, acts very much as water does in regard to this mode of motion, and I believe myself that on a level bed, whatever the slope of the upper surface of the ice, there is virtually no motion at all in the lowest layers. This view, I know, is shared by most physicists, and it is quite preposterous in the great mass of Glacial geologists to habitually ignore the stubborn fact in their iterated statements. The burden of proof lies upon them. Before a postulate is admissible in science at all, its reasonableness and its accordance with the ordinary laws of nature ought to be made out, and until they be made out the theory can have no permanent place in science; and this is at present the position of the theory of ice-sheets moving over hundreds of miles of level surface, as continually postulated. It is, in effect, an appeal to the reversal of the laws of nature.

Let us grant, however, that the orthodox geologists are right, and that on *a priori* grounds even, they have a serious case; and let us go on to examine some of the concrete facts that have to be explained under any circumstances. First, what is the kind of treatment which stones entrapped between a glacier and its bed are likely to receive? There is a school of geologists who argue as if it were possible, or even conceivable, that a great mass of almost solid ice, pressing down with the pressure of many tons to the square foot, can in some way disintegrate its own bed and drag up fragments of stone out of it, as a carpenter takes old nails out of a box. Then Mr. Carvill Lewis speaks of "a deposit composed of fragments torn by the glacier from the basement rock over which it passes." How this extraordinary proceeding is to be done I know not, nor have I ever seen any attempted explanation of it, and until some explanation of some kind is forthcoming I shall continue to treat it as an impossibility. Another set of geologists urge that, in some way or other, stones can travel upwards through glacier ice, and so rise from its base to its surface. Here, again, the whole proceeding seems incredible to anyone who analyzes what a moving viscous body really does with the solid materials it comes across, and what it would have to do to overcome gravity in this way.

It is quite true that stones sometimes occur imbedded in the mass of a glacier, and afterwards appear at its surface, and thus superficially seem as if they had travelled upwards; but this is due to a very different process. If a stone falls down a crevasse, and is arrested before it reaches the floor of the glacier, it will, when the crevasse closes up on level ground, be imbedded in the ice. If, again, a stone or a group of stones lie on the back of a glacier, and a succession of snowfalls come upon it, which snow is converted into ice subsequently, it or they will become imbedded in solid ice, and in this way so-called englacial drift may be formed. When by ablation or by the direct rays of the sun a certain quantity of the surface of the glacier is subsequently removed, these imbedded stones will appear, like the imbedded remains of the famous Austrian travellers lost three centuries before they appeared on the surface of the Glacier of Thisdul in 1885; but this is not by any process of travelling upwards through the ice from its bed to its surface, for which no mechanical explanation seems in any way available, but by the uncovering of what was always in mid-ice. What is true of travelling upwards is equally true of travelling downwards, or perhaps more true, for it involves the stones travelling from less to more dense strata of ice, and from layers under slight pressure, and therefore friction, to layers under great pressure and great friction. The stones will, in fact, move with the layers in which they are imbedded, and when a glacier is moving on *a rapid slope*, as Spencer noticed by going underneath such a glacier in Norway, the scattered stones, *even at its base, will be slowly moved*—very slowly, since he noticed that the ice itself, which at this level crept very quietly, and the layers above, were apt to move over the stones and to have gashes cut into themselves by them. *This was on a steep slope.* On level ground, as I have said, the capacity of the nether layers of any ice mass which we can conceive of, for any appreciable motion or for exercising any appreciable thrust upon the stones beneath it, is most doubtful.

But let us pass on, and suppose it had the capacity. What must happen? A stone falls to the bottom of a crevasse. The ice begins to move, and the stone is rapidly enveloped in ice, and is held in its grasp as in a vice. As the ice moves on and exercises a certain thrust upon the stone, it will act like the slipper or skid of a coach, and its lower surface in contact with the glacier's bed will be worn down and smoothed and polished. If presently the stone be arrested by some obstacle, and the ice flows over it, it will in some measure also rub down the rugosities of the upper surface, but probably not to the same extent. The stone will thus have two more or less parallel faces—one a good deal smoothed, and the other not quite so much—but the other angles or edges of the stone will remain intact, and unrounded and unsmoothed. We cannot understand how by any process a glacier can make a true boulder with subangular edges or a curved outline all round, or in the case of soft polygonal stones polish and smooth the different facets as well as the angles. This rounding and smoothing and blunting of angles have always been attributed to water, and I take it that conclusion is generally held still.[1]

Now the remarkable part about the boulders in the surface beds of Eastern England, those of local origin as well as the foreigners, is that they are all either subangular or rounded. The true glacier type of skidded flat stone, I have never seen there, nor have I seen specimens of those enormous sharp-edged erratics which have never left the glacier's back until they were finally laid to rest. The only large blocks are the local ones, while the far-travelled foreigners are not only small in size, but greatly rounded and worn, while those which have travelled less have their angles still preserved, but they are blunted and rubbed down by rolling into subangular forms. This, so far as I know, is universal. How, then, can we attribute these boulders to ice-portage? If they had come on the back of the glacier they should be completely sharp and fresh, and we ought to have a great many of them of very large size indeed, especially the crystalline boulders. A mass of ice can carry a load as big as a house just as well as a pebble, but the crystalline boulders are nearly all small. It is only the local rocks that occur in fairly large masses. Nor, again, ought they (as they are) to be sorted roughly according to their size, so that we find them as a whole diminishing in size as we get away from their source. This is not the fashion with ice-portage at all, as a very casual visit to a living glacier and a living moraine will prove. There the biggest stones are often found in the most remote moraines, having travelled the furthest. But we are told these stones are sometimes scratched, and in the case of the soft stones not infrequently scratched, and that must surely be due to ice. So they are scratched. The absurdity to me is the conclusion that the majority of these scratches were made in any way by ice, or that ice could possibly have had a part in the work. Let us look a little more closely than is usually done by those who cling to ice, as a drowning man is said to cling to a straw, without ever considering its actual handiwork.

When ice first enters a valley with rough and torn edges to its rocks, it proceeds no doubt to rub these rough places down and to smooth them, and to remove the parts that cause friction until it creates for itself a smooth and polished bed as a river does. The result of this action is the pouring out at its foot of a considerable quantity of mealy water. This part of the work is, however, presently finished, and, except where the slope is great

[[1] It is well to bear in mind the intimate connection between ice and water-action going on in a glacier. Thus, in summer the runlets of water, which form upon the surface of the ice, gradually form streams which fall down some crevasse through the ice to the bed of the glacier, and, acting with a gyratory motion upon the angular stones and gravel, may produce not only hollows in the floor of the glacier, but also rounded boulders, often of considerable size. These in time find their way down the ice-stream to the terminal moraine of the glacier. Thus it is often difficult to separate the action of ice from that of water in such cases.—EDIT.]

and where the ice probably moves *en masse*, it ceases to denude altogether, having made for itself a virtually frictionless route to travel over, just as a river only denudes in its torrential parts. If an angular stone falls down a crevasse and reaches the bottom, and if being held by the ice it is pressed against the polished bed of the glacier, it will no doubt, if hard enough, score and scratch it with any of its projecting angles or edges, just as emery paper will scratch a piece of polished brass. How, on the other hand, the polished and smooth bed of the glacier is to scratch and score the loose stone in the ice—that is to say, how the polished brass plate is to scratch the emery paper—I do not see at all. It may rub off some of its projections, but how a smooth surface can scratch anything passes my comprehension. Occasionally two angular loose stones may press against each other under a glacier and scratch each other, but this must be a very unusual occurrence, and the best proof of it is what has been remarked over and over again, namely, the comparatively small number of scratched stones in true living moraines, the workshops which the glacial theorist carefully avoids. This is not all. The great majority of the stones from the Eastern Counties on which I have seen scratches are the native soft rocks. The number of hard crystalline boulders of foreign origin on which I have noticed scratches is very small indeed. In all cases the scratches have occurred on stones more or less rolled, and in the case of the polygonal chalk boulders not only on rolled boulders but on boulders with polished facets. These scratches were certainly made contemporaneously with or subsequently to the rolling which destroyed the angles and polished the surface of the stones. If so, how could ice be the agent which produced them. We cannot well postulate an ice-sheet in Norfolk and Suffolk dragging in to itself rounded and polished stones from the open waters of the North Sea, where the boulders were being rolled and smoothed in order to give them a few finishing touches. The process seems absurd. The fact is, these scratched stones have become a fetish. The glacialist naturally wants to find if he can a simple and ready test of the work of ice, and he has jumped at this particular test as a very convenient one, when as a matter of fact it is no test at all. He has followed a false scent in supposing that the scratches on loose stones have any analogy to the scorings and groovings on the smooth beds and side-walls of glaciers, which they have not. The very fact of there being a considerable number of scratched stones in a bed of clay or sand is a proof that that bed is unlike a moraine, and not that it is like it. The many bruised faces and black eyes which are to be seen in Clare Market are not, as some glacialists would argue, the results of the battle of Waterloo—where there were many wounds inflicted, but not many of that kind. To sum up this part of the case, there is no single feature known to me in the foreign boulders of Eastern England, any more than there is in the domestic and native ones, to justify us in attributing them to the handiwork of ice. They are simply a number of more or less waterworn boulders, such as occur in mountain torrents where crystalline rocks abound, where some of the stones are completely rounded and others are blunted and subangular.

But we are asked, how can you account for their portage except by ice? What other force was capable of bringing them to where they are found from places so distant as Norway and Denmark? I reply that whatever force brought them it could not possibly have been ice, for several very potent reasons, to which we will now turn. The first reason is, that the foreign stones do not all come from the same direction; and as they are found in the same beds mixed together, it seems impossible to attribute them to the portage of ice, which moves along perfectly defined fixed lines of least resistance. Mr. Goodchild, it is true, fathered some years ago an extraordinary theory according to which there could be currents flowing athwart each other in a great mass of almost solid matter like ice. I do not know whether he still holds this view or not. To me it was, and it remains, incomprehensible. It is quite true that when a glacier is coming down a wide valley with a slight momentum, and is joined by a subsidiary glacier from an influent valley (which may be steeper), the intruding glacier, whose flow is more rapid, will thrust the other glacier back for a short space, and it will appear as if the ice were moving in two directions, and this will continue so till the two ice-streams have coalesced. But this, which is a perfectly simple and credible mechanical process, and only involves the adjustment of two rivers of ice with initially varying force and direction when accommodating themselves to a common path, is a very different matter to divergent currents *arising* or existing in ice-sheets and being continued in them when the ice is supposed to be moving across natural obstacles. Such a process, and the thrusting back of one glacier by another, is very different to currents of ice crossing each other in a great ice-mass. Such a process is to me incredible, nor have I been able to find any physicist to credit it. If we cannot appeal to divergent currents in the ice, how are we to explain the bringing together of stones from contrary directions to the same place by means of ice?

(*To be concluded in our next Number.*)

VII.—The Exfoliation of Gneiss in Brazil.

By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

PROFESSOR J. C. BRANNER has written a most interesting and valuable treatise on the "Decomposition of Rocks in Brazil," of which he has kindly sent me a copy.[1] All who want to study agencies of decomposition and denudation as they act in tropical countries cannot do better than read Professor Branner's clear and well-digested exposition, illustrated as it is by excellent reproductions of photographs and by figures and diagrams.

Among the many remarkable effects brought about by changes of temperature and decomposition in the gneissic rock-masses of Brazil, perhaps the most striking is the large scale on which exfoliation takes place, producing, in combination with other agencies and with structure, characteristic topographic rounded forms or bosses and conical peaks.

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[1] "Decomposition of Rocks in Brazil": Bulletin Geo. Soc. America, vol. vii, pp. 255–314, pls. x–xiv.

Among many illustrations Professor Branner mentions a rounded peak just east of the Corcovado, where the "surface has flaked off in great sheets that have slid down the mountain slopes." In the Gavêa (plate xii) these scales wrap round the peak, and it is remarked as a noteworthy feature in the exfoliation of peaks that "the flakes came to a feather edge on the downhill side so that they overlap each other like gigantic scales."

After referring these characteristic scalings to what is no doubt their true cause, expansion and contraction aided by decomposition along fractures, Professor Branner gives a table of the linear expansion of gneiss at several temperatures, taking one part in every 200,000 as its average expansion for one degree Fahrenheit, which shows that a rise of 103° would produce a lengthening of 1·854 inches, and 10° of 0·18 inch.

Evidence is brought to show that the maximum variation of temperature in Brazil is 100°, on which Professor Branner remarks: "It must be confessed that these figures are disappointing, for they lead one to suspect, if they do not show, that exfoliation, on account of changes of temperature and where small areas are exposed, is not so active an agency in Brazil as the exfoliated peaks and boulders constantly suggest."

One of my objects in calling geologists' attention to this excellent paper is to point out that the *cumulative* action of these recurrent expansions and contractions seems to have been lost sight of. So long ago as 1888 I gave instances in this Magazine[1] showing that the effect of ordinary daily alternations of temperature on terra-cotta copings set in cement was in time to produce permanent lengthening. I have been observing the phenomena in many examples since, and I pointed out some of these copings at Blundellands to Professor Lapworth and other geologists when on an excursion of the British Association at the Liverpool Meeting last year. I find that the lengthening proceeds very slowly from year to year, that it takes place in the summer, and to the greatest extent in the hottest weather, and not appreciably in the winter. I attribute it largely to the stresses set up by the greater expansion of the heated top surface over that of the under-surface. The natural tendency of this differential expansion is to hog up the coping, but this being resisted by its weight the underside is strained and lengthened, the forces being directed longitudinally, and the hogging up taking place at a fractured joint or at a ramp, if there be one, in the coping.

Few people, I fancy, have any conception of the enormous silent force which is developed by even a small rise of temperature. In the case of rolled iron Sir B. Baker estimates it as a stress of a ton per square inch for every 12° Fahrenheit. Though there are no data that I know of on which to estimate the stress set up in gneiss or terra-cotta by a given rise of temperature, we can see that it cannot be otherwise than severe.

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[1] "Effects of Alternations of Temperature on Terra Cotta Copings set in Cement," etc., pp. 26, 27.

This is the suggestion that I have to make:—The direct heat of the sun in Brazil must greatly exceed that in this country, and the range between the temperature of the gneissic rocks with the sun in the zenith and the temperature of the same during midnight radiation must be very considerable. Now, according to my studies, this is the very thing wanted to produce disruption. The surface of the gneissic rock becomes greatly heated during the day, but this daily range of temperature cannot extend far into the rock (unfortunately I know of no experiments to determine the depth); consequently the difference of expansion between the upper and under layers creates shearing stresses, which, being renewed daily year after year, eventually shears the rock, quarrying out a bed or sheet of a thickness determined by several factors, in the same way that the cement bed of a terra-cotta coping by recurrent daily expansion of the coping is sheared along its whole length. Once the minutest fracture occurs, water and chemical agents, as so well set forth by Professor Branner, detach the large sheet or scale from its parent rock.

Shortly stated this appears to me to be the origin of these huge exfoliated scales and the "sheets of rock, sometimes 15 feet thick," "utilized by the quarry-men in breaking out blocks of convenient sizes," but which "sheets are more commonly from 2 to 10 feet thick," and "often as thin as a knife-blade."

It is the recurrent stresses that eventually break up the rock, for on each expansion the rock is strained, and it does not recover its exact original condition on contraction. As field-geologists, we all know that an obdurate rock may resist one great blow of a hammer, but yields to repeated lesser blows; and it is this daily and yearly recurrent straining of the gneissic rocks of Brazil that in my opinion finally shears off large plates, and produces the topographic features so characteristic of that country.

VIII.—THE RANGE OF SPECIES IN THE CARBONIFEROUS LIMESTONE OF NORTH WALES.[1]

By G. H. MORTON, F.G.S.

ATTENTION having recently been directed to this subject, I have been induced to present the results of many years' collecting in the Carboniferous Limestone of North Wales. The formation there presents four well-defined subdivisions, each of them, with the exception of the highest, having distinct lithological characters, viz.: Lower Brown Limestone, Middle White Limestone, Upper Grey Limestone, and the Upper Black Limestone. Lists of the fossils have been made, collected more or less continuously along the country from each subdivision.

[1] Read before the British Association, Section C, Liverpool, 1896.

In North Wales the occurrence and succession of the species in the subdivisions vary in different areas, and the larger the area examined the more difficult it becomes to find species peculiar to certain horizons. In order to obtain a definite result I have compiled three separate lists of the species obtained in that number of distinct areas. There are the Llangollen, the Flintshire, and the Vale of Clwyd Lists. Each of the lists shows the relative scarcity and abundance, and the range of the species in the subdivisions; and although future search will doubtless add to the rare and occasional species, the number and range of the common and very common must be very nearly correct. Neither the rare nor the occasional species are of much use in defining distinct horizons in consequence of their rarity, and it is only the common and very common species that can be expected to indicate a definite horizon or zone. In North Wales a great difficulty arises from the occurrence of all the common and very common species in the Upper Grey Limestone, with the exception of *Productus comoides*, and although all pass downwards, they become scarce in consequence of the general paucity of fossils in the inferior subdivisions.

In the Llangollen List there are 69 rare, 28 occasional, 16 common, and 27 very common species. Deducting Foraminifera, which are not in the other lists, there are 36 species that are common and very common, and they all occur in the Upper Grey Limestone, with the exception of *Posidonomya Gibsoni* from higher strata, and *Productus comoides* in the Lower Brown Limestone, all the other species in the list being rare and occasional forms.

In the Flintshire List there are 92 rare, 35 occasional, 30 common, and 11 very common species; and of the 41 common and very common, 37 species occur in the Upper Grey Limestone, 3 of the remaining species, *Posidonomya Becheri*, *Aviculopecten granosus*, and *A. papyraceus*, occurring in the Upper Black Limestone, and *Productus comoides* in the Lower Brown Limestone.

In the Vale of Clwyd List, which includes the Great Orme's Head, there are 16 rare, 22 occasional, 12 common, and 10 very common species; and of the 22 common and very common, 21 species occur in the Upper Grey Limestone, the exceptional species being *Productus comoides*. None of the 21 species are peculiar to the subdivision, for they all occur in the underlying Middle White Limestone. The number in the list is less than in the others, on account of the Upper Grey Limestone having been considerably denuded in the Vale of Clwyd.

Nearly the whole of the common and very common fossils occur in each of the three lists, for there are few that are not found in all the areas.

Of the numerous common and very common species found in the Carboniferous Limestone of North Wales, it is impossible to find any that are restricted to horizons of less importance than the subdivisions into which the formation is naturally divided. An examination of the first appearance and continuity of the species seems to indicate that they were introduced from some pre-existing area, and that the upper beds of the formation are more recent than in Derbyshire and Yorkshire, where the thickness of the Limestone is very much greater.

The sudden appearance of species in restricted areas, like those found in the Upper Grey Limestone at Axton, in Flintshire, where 20 species occur, and at Graig-fawr, in the Middle White Limestone, where six species occur, not found elsewhere in North Wales; and the early appearance of three species in beds of Black Limestone and shale at the base of the Middle White Limestone at the Great Orme's Head, seem to indicate migration from some other area. The latter species are *Orthis Michelina*, *Spirifera humerosa*, and *S. rotundata*. *Spirifera humerosa* had only been previously found at Llangollen and in Flintshire, while *S. rotundata* was rare in North Wales; but none of the three species had been previously found at a lower horizon than the Upper Grey Limestone. *Productus giganteus* first appears in the Lower Brown Limestone, and very large specimens occur within 50 feet from the base at Moel Hiraddug, a few miles from Rhyl. The species occurs all through the Carboniferous Limestone, and thousands may be seen in the Upper Grey Limestone.

In this paper the range of the species found is confined to North Wales, but when the subdivisions of the Carboniferous Limestone in other parts of the country are worked out, and the species from each tabulated, it will be interesting to compare the result with that obtained in North Wales.

REVIEWS.

I.—PUBLICATIONS OF THE PALÆONTOGRAPHICAL SOCIETY. Vol. L, 1896.

THE fiftieth issue of this well-known Society maintains the high character of the previous annual volumes, and augurs well for the future prosperity of this useful body. The volume contains, in addition to the usual catalogue of memoirs already published, and other matter of general interest, an extract from the Report of the Council to the Annual General Meeting held on June 19, 1896. This Report was noticed by us in the GEOLOGICAL MAGAZINE for September last (Dec. IV, Vol. III, 1896, pp. 385–388, Pl. XIII); we only call attention to it here in order to reproduce the portrait of another of the founders of the Society therein referred to, namely, Dr. J. Scott Bowerbank, F.R.S., F.G.S., who was Secretary from May, 1847, to 1862, and President from 1865 to 1876.

Like most of its predecessors the volume is a composite production, containing—

1. *Part III* of "The Crag Foraminifera," by Professor T. Rupert Jones, F.R.S., F.G.S.; assisted by Messrs. H. W. Burrows, C. D. Sherborn, F. W. Millett, R. Holland, and F. Chapman. (pp. 211–314 and pls. ix–xii; the plates do not accompany this part of the text.)

2. "British Jurassic Gasteropoda," Part I, No. 9, Gasteropoda of the Inferior Oolite (pp. 445–514, pls. xli–xliv), by Wilfrid H. Hudleston, M.A., F.R.S., V.P.Pal.Soc. (Completed with title-page and index.)

3. "A Monograph on *Carbonicola*, *Anthracomya*, and *Naiadites*," by Wheelton Hind, M.D., B.Sc.Lond., F.G.S., etc. (Part III, pp. 171–182, pl. xxi; completed with appendix and index.)

Yours truly
J S Bowerbank

4. "A Monograph of the British Carboniferous Lamellibranchiata," by Wheelton Hind, M.D., B.Sc.Lond., F.G.S. (Part I, Mytilidæ, pp. 1–80, pls. i, ii.)

5. "A Monograph of the Devonian Fauna of the South of England," by G. F. Whidborne, M.A., F.G.S. (Vol. III, Part I, Fauna of the Marwood and Pilton Beds of North Devon and Somerset, pp. 1–112, pls. i–xvi.)

1. The Crag Foraminifera, Part I, was commenced in 1865 by Prof. T. Rupert Jones, F.R.S., assisted by W. K. Parker and H. B. Brady (pp. 1–72). One page (p. 73), which completes this part, was issued in 1895 with Part II. The second part was begun in 1895, with five new assistant authors, as stated above—the two early colleagues who shared in the labour of Part I having in the intervening thirty years both passed away, leaving Professor Rupert Jones to seek new assistants. These he has fortunately found in increasing numbers, so that the work might now be known as the "*hexade*" or the "*hexameron*"; and if each of the six authors contributes his quota, the work should proceed "merrily as a marriage peal."

Plates i–iv appeared with the text to Part I in the 1865 volume, and plates v–vii with the text to Part II in 1895, so that the statement on p. x in Part III, 1896—"list of genera and species described and *figured* in Part III"—is hardly correct, seeing that no plates accompany Part III.

We venture to urge upon authors the desirability of making parts of monographs complete in themselves, especially when, as so often must happen, there comes a hiatus of years between the issue of parts of a monograph.

In Parts II and III of this monograph on the Crag Foraminifera, the authors give not only careful descriptions of a large number of species, but Mr. Burrows has added an interesting chapter "On the Stratigraphy of the Crag, and notes on the Distribution of the Foraminifera," which must prove of great value to geologists. The synonymy has been dealt with by Mr. Sherborn, and we see the terrible consequences arising from the want of his "*Nomenclator Zoologicus et Palæontologicus*" to refer to at any moment, in the long lists of synonyms which fill pages of text in such forms as *Truncatulina lobatula*, *T. variabilis*, *T. Haidingeri*, and *T. Ungeriana*; or in *Globigerina bulloides*, *Planorbulina Mediterranensis*, *Polymorphina communis*, *Textilaria sagittula*, *T. agglutinans*, etc. Every palæontologist must feel grateful to the authors for their excellent work, leading the way to a better knowledge of the forms of these micro-organisms of our English Crag.

2. The British Jurassic Gasteropoda, by Wilfrid H. Hudleston, M.A., F.R.S., etc. The completion of this task, which has occupied ten years in its publication, to say nothing of previous study, must be a source of satisfaction to the author as well as to palæontologists, field-geologists, and collectors of fossils.

That the Gasteropoda of one formation, the Inferior Oolite, should occupy a volume comprising nine parts, 44 plates, and 514 pages, is a sufficient evidence of the growth of palæontological knowledge. Morris, in the second edition of his famous Catalogue, recorded sixty species; the present census enumerates 398 species and 40 varieties from the Inferior Oolite.

In these days of excessive species-making and of the consequent obliteration of old landmarks, it is satisfactory to find that the author adopts a plan of judicious moderation both as regards species and genera. He remarks that "when once the doctrine of Evolution is admitted in its entirety, the ideas attaching to such expressions as 'genus' and 'species' lose somewhat of their definition. Nevertheless, they are necessities in classification; and even if they do not absolutely exist in nature, it becomes necessary as by a sort of legal fiction to presume that they do exist for purposes of scientific arrangement."

The author speaks favourably of the trinomial system, but considers it would be unwise at present to depart from the old course, not, however, because the binomial system was the more philosophic or the better. "We must jog on as well as we can with the help of sub-genera and var. *a* and var. *b*, and this no doubt can be done without any difficulty." In this way the number of species is kept down, and the subject remains free from that complexity which must attend an undue multiplication of names. Even sub-genera, when introduced, are rightly kept within parentheses, as in the case of *Nerinæa* (*Nerinella*) *gracilis*, *Nerinæa* (*Ptygmatis*) *pisolitica*, *Turritella* (*Mathilda*) *opalina*, etc. The author further observes with regard to the classification of the fossil Gasteropods, that the subject must be treated from a conchological point of view: "we must fall back upon the shell as the basis of classification of our fossils, and accept such aid from zoology as is consistent with the material at our disposal."

With regard to palæontological horizons, the author remarks that "From their uncertain and unequal distribution, and also from the fact that Gasteropoda have been greatly influenced by the physical conditions that obtained during the period of deposition, it is probable that they are of less value as indicators of horizons than the Cephalopoda, the Ammonites especially. Moreover, with the exception of one or two groups, such as *Nerinæa*, their mutations have been much less rapid, so that forms have been more enduring, and thus sundry demoid common types may be said to pervade nearly all the beds."

The author proceeds to give us an excellent account of the stratigraphical features of the Inferior Oolite in its range from Dorsetshire to Yorkshire. He has himself studied the rocks and their fossils at most of the important localities, and has, moreover, employed a fossil-collector to make diligent search, so that he has accurate knowledge of the horizons of nearly all the species that have come under his notice.

The Inferior Oolite is divided into two broad divisions as follows:—

	Zones.
Upper Division	*Ammonites Parkinsoni.* ,, *Humphriesianus.*
Lower Division	,, *concavus* (subzone). ,, *Murchisonæ.* ,, *opalinus.*

Other local zones and fossil-beds are duly indicated in the detailed accounts of various sections, so that this introductory essay on stratigraphy is full of interest and value to the student of Jurassic geology. At the commencement of the work the author adopted the term "*Sowerbyi*-subzone" for the highest bed of the Lower Division, though not without protest. Subsequently he realized that this important life-horizon should bear the name of its most characteristic Ammonite, *A. concavus*. The *Sauzei*-bed, which is much more nearly on the *Sowerbyi*-horizon, forms the base of the Upper Division, and is included broadly in the *Humphriesianus*-zone.

Among the species described are two fresh-water forms—*Paludina Langtonensis* and *Valvata comes*: these come from a "mortar-like deposit," apparently the ancient decomposed surface of the Chipping Norton Limestone. Associated with them there is "apparently a Bathonian fauna," so that the evidence tends to show that these fresh-water forms may belong to the (local) base of the Great Oolite Series.

In a footnote (on p. 492), the author describes a new genus from the junction-bed of the Middle and Upper Lias at Thorncombe, Dorset, naming it *Wilsonia Liassica*, in honour of Mr. E. Wilson. The species is figured on plate xliv.

3. Dr. Wheelton Hind's monograph on *Carbonicola*, *Anthracomya*, and *Naiadites* (Part III) is brought to a termination, and completed with one plate, an appendix, and index.

4. Dr. Wheelton Hind commences a fresh monograph on the British Carboniferous *Lamellibranchiata*: why this new departure? Could not the earlier described forms have been included in the later and more embracing title? The plates by Mr. A. R. Searle are admirable. The author deals in his Introduction with the horizons in the Coal-measures in which molluscan fossils occur; he then gives a bibliographical sketch of the works which have been already published dealing with the fossils of this formation; commencing with the Rev. David Ure's classic work "The Natural History of Rutherglen" (1793); and adding descriptions of the species of *Modiola* and *Lithodomus*. We shall notice Dr. Wheelton Hind's work again later on.

5. The Rev. G. F. Whidborne continues his monograph on the Devonian Fauna, taking up in this volume the Fauna of the Marwood and Pilton Beds of N. Devon and Somerset. The author deals with fish-remains in the form of scales of *Holoptychius* from Ashford; a new Myriopod named *Cariderpestes gyius*, an obscure form, possibly part of a *Euphoberia*? but difficult to determine. We have also Phyllocarids; a supposed cirripede (*Anatifopsis*); three Trilobites (*Brachymetopus*, *Phacops*, and *Phillipsia*); numerous Ostracods; and many Mollusca; carefully illustrated in sixteen plates. We cannot but admire Mr. Whidborne's industry and energy in working out, both in the field and in the study, the fauna of his own Devonian formation, and making so many fossils known, by means of figures and descriptions, from these ancient rocks.

II.—Faunas of the *Paradoxides* Beds in Eastern North America. No. 1. By G. F. Matthew.[1]

In this article, which deals with the smaller crustaceans, including the genera *Agnostus* and *Microdiscus*, there is a definite attempt to correlate the several subfaunas of *Paradoxides* which occur in America with those found in Europe. Of the six subzones into which the *Paradoxides* beds of Sweden have been divided, the above author recognizes four as existent in America. Of these the second has been recognized by its fauna in New Brunswick, Newfoundland, and Massachusetts; the first has been found only in the province first-named, and the fourth in Newfoundland.

Some facts relative to the development of the larval forms of *Agnostus* and *Microdiscus* are given, which indicate a nearer relationship between these genera than is apparent from the adult individuals. The pygidium in *Agnostus*, as shown from the larvæ, had three stages of growth; the earliest marked by the posterior, obscure somites of the posterior lobe of the rachis, the second by the two anterior somites of the same lobe, and the third by the two anterior lobes of that rachis. In the head-shield the occipital ring is usually quite aborted and the true posterior lobe largely suppressed; the so-called posterior lobe is thus a fusion of the middle lobes of the glabella. The anterior lobe becomes more definite and prominent than in most trilobites.

A new species of *Microdiscus* of the *Olenellus* fauna is described, differing in its short glabella (and cephalic shield) from the other *Microdisci* of that fauna; attention is called to the resemblance of its head-shield to that of the forms with long occipital spines that are prevalent in the *Paradoxides* beds, and the suggestion is offered that it may be of the same stock as that from which they are descended. The *Microdisci* of the *Olenellus* and *Paradoxides* beds are classified in this article and divided into subgenera, their relation to each other being shown by an analytical table, descriptive of the various parts of the head-shield and pygidium. *Stenotheca* of Salter is claimed to be crustacean, and *Plumulites* of Barrande is said to occur in the *Paradoxides* beds of Newfoundland. Four plates, with full descriptions of the figures, accompany the article.

REPORTS AND PROCEEDINGS.

◆

Geological Society of London.

I.—January 20. 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Glacial Phenomena of Palæozoic Age in the Varanger Fiord." By Aubrey Strahan, Esq., M.A., F.G.S.

The Gaisa beds of the Varanger Fiord consist of slightly altered quartz-grits, with red sandstones and shales, and rest upon a deeply denuded surface of the metamorphic rocks. In a section, first noticed by Dr. Reusch, a heterogeneous mixture of grit and clay with boulders of granitic and other rocks is seen to be intercalated between the quartz-grits, the bedding of the overlying grit proving that this boulder-rock was contemporaneously formed, and not subsequently wedged in. The surface of the grit below the rock is characteristically glaciated. Proof is given that the striated surface is not the floor of a thrust-plane, and that the boulder-rock is not a fault-breccia or a crush-conglomerate, but a "till." In the absence of fossils the Gaisa formation is doubtfully assigned to an early Palæozoic age. It exhibits the same sedimentary characters as the rocks of later date in other parts of the world in which glacial phenomena have been observed. The glacial episode is attributed to a temporary change of climate rather than to the high latitude in which the section lies.

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[1] Trans. New York Acad. Sci., vol. xv, sig. 12, August 3, 1896.

2. "The Raised Beaches and Glacial Deposits of the Varanger Fiord." By Aubrey Strahan, Esq., M.A., F.G.S.

The Raised Beaches range up to nearly 300 feet above the sea. Though a number of impersistent shingle-banks occur at various heights, the highest is constant, and can be traced along the same level either as a shingly terrace or by a zone of wave-worn rocks. Evidence is furnished by the relative size of different parts of the beach that the prevalent wave-action was from the west, and by the greater abundance of erratics on or below the beach than above it, that floating ice was at work.

At the head of the fiord a blue clay dotted over with stones is now being formed, and the raised beach there consists of a similar material. Both here and elsewhere this clay simulates a Boulder-clay; but for reasons given it is believed to be a marine fiord-deposit, into which many stones have been dropped by floating ice.

Deposits of true glacial age, in the form of mounds of gravel, are described, and shown to have yielded the material out of which parts of the Raised Beaches are formed. The glaciation of the fiord is attributed to floating ice, and is shown to have taken place before the formation of the Raised Beaches, at a time when the sea surrounded this part of Finmark, by way of the Varanger Fiord, the Tana Valley, and the Tana Fiord.

II.—February 3, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "The Subgenera *Petalograptus* and *Cephalograptus*." By Miss G. L. Elles. (Communicated by J. E. Marr, Esq., M.A., F.R.S., F.G.S.)

The forms referred to in the paper are accepted as subgenera of *Diplograptus*, as defined by Lapworth. The two subgenera have frequently been much confused, but examination of specimens preserved in relief shows that they have very distinctive characters, especially at the proximal ends. The author gives diagnoses of the two subgenera, and detailed descriptions of the following forms:—

Petalograptus folium, His.; *P. palmeus*, Barr., and varieties *latus*, Barr., *tenuis*, Barr., *ovato-elongatus*, Kurck; *P. ovatus*, Barr.; *P.*, n.sp.; *Cephalograptus cometa*, Gein.; and *C.*, n.sp.

She concludes that *Petalograptus* has been derived from *Orthograptus foliaceus*, *O. truncatus* having been a step on the way. The latter form has an almost horizontal connecting-canal, so that the first of the second series of hydrothecæ arises at nearly the same level as the first of the primordial series; whilst, if the connecting-canal became more oblique and the thecæ more concavely curved, a form identical with *P. palmeus* would be the result. Further changes would give rise to *P.*, n.sp., and subsequently to *P. folium*. When the first theca of the second series arises so late that the sicula is entirely free on the side remote from that on which the first of the primordial series arises, an important stage is reached, and the form becomes a *Cephalograptus*. Such a form is furnished by *C.*, n.sp., which is in some respects intermediate between *Petalograptus* and *Cephalograptus*. The extreme form is reached in *C. cometa*, in which the first hydrotheca of the second series is still later; the hydrothecæ are still longer than those of earlier forms and almost parallel to the long axis of the rhabdosoma. The other known forms of *Petalograptus* may have been derived from *P. palmeus*.

It seems exceedingly likely that the *Petalograpti* had a *Phyllograptus* as a remote ancestor, but the evidence for this is not yet complete, nor can the author state whether *Cephalograptus* had a further stage in the form of *Dimorphograptus*.

2. "On some Superficial Deposits in Cutch." By the Rev. J. F. Blake, M.A., F.G.S.

The author arranges the deposits of which he treats under the following heads: (1) Subrecent Concrete; (2) Boulder Beds associated with the former; (3) Quartzite Reefs; (4) Infratrappean Grits; (5) Laterite; (6) Alluvium and Rǎun.

(1) The Subrecent Concrete consists of a calcareous, porous, laminated sand with milioline remains, which extends to a height of about 700 feet above the Rǎnn, and has a discontinuous distribution. The author gives reasons for regarding this as an æolian deposit, partly derived from recent marine accumulation and blown inland and uphill by the prevalent winds.

(2) The Boulder Beds are next described, their distribution noted, and their occurrence with æolian deposits recorded. The author argues that the æolian deposits once had a greater slope, and acted as carriers, so that, under the influence of rain, the stones from the hills slipped to their present position.

(3) The Quartzite Reefs are described as filling up cracks; the material is of æolian origin and derived from the surrounding rocks, and owing to this material having been formerly at a lower level than the latter, water stood on it for a sufficiently long time to permit of the materials being cemented by a siliceous deposit, and converted into quartzite.

(4) The Infratrappean Grits are maintained to be superficial deposits on the pre-trappean land-surface, some being the ordinary results of weathering, others due to the washing down of débris to a water-covered level, and others again simply æolian drift. It is thus seen that there has been constancy in the meteorological conditions of Cutch from recent times as far back as the Cretaceous period.

(5) The Laterite-deposits of the district occur to a height of only 120 feet above the Rănn. There is evidence that they were laid down in water at a time when the surface of the country was not very different from the present one. The material may have been partly derived from Jurassic rocks, but some of the constituents, as the eroded agates, must have come from the trap-rocks.

(6) The Rănn is an area which has recently been abandoned by the sea, owing to unequal movements, but there is evidence that deposit has also taken place in it, and the depression has become shallower, so that in course of time the whole surface will be made of alluvial or æolian soil.

III.—February 24, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Nature and Origin of the Rauenthal Serpentine." By Miss Catherine A. Raisin, B.Sc. (Communicated by Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.)

This serpentine has been already described by Herr Weigand as one of those which occur in regions of gneiss or schist related in their origin to those rocks. In order to test this hypothesis as to the formation of the serpentine, the author has examined the district, and has studied its rocks with the microscope.

Herr Weigand asserted that transitions could be recognized from typical gneiss to a peculiar amphibolite, and that the latter rock has been changed to serpentine. The author could find in the field no evidence of a passage from gneiss to amphibolite, and calls attention to the general difficulty of the supposition. She states that when the serpentine is examined microscopically, the greater part shows the usual appearance of serpentine derived from olivine, and can be distinguished from included parts, which have resulted from change in hornblende or other pyroxenic constituents. Further, that several accessory minerals occur which are usually found in peridotites. The rock also contains a peculiar chlorite. This she thinks the result of the modification of a biotite, for the latter mineral occasionally occurs as a constituent in a neighbouring serpentine, and both there and in the Rauenthal, intermediate forms apparently can be detected. It seems to her that the chemical analyses already published are not in harmony with the supposed change of a hornblende rock into serpentine.

While it is true that a hand-specimen sometimes shows a transition (generally rapid) from a rock consisting mainly of hornblende to one which has consisted mainly of olivine, she maintains that this appearance is far more consonant with partial differentiation of the original magma, followed by fluxional movements and flow-brecciation. It is not that a mass of amphibolite passes into one of serpentine, but that a specimen of the latter is occasionally streaked by the former.

By comparison with other serpentines of the Vosges and elsewhere, which are admittedly developed from olivine rocks, so much likeness is found between them and the Rauenthal mass, that the origin must be similar.

2. "On two Boulders of Granite from the Middle Chalk of Betchworth (Surrey)." By W. P. D. Stebbing, Esq., F.G.S.

The author notices cases of occurrence of boulders in Chalk which have been previously described; and records the occurrence of two boulders which were obtained from the Chalk of the zone of *Terebratulina gracilis*. The larger weighed 7 lb. 7 oz., and measured 5″·8 × 6″·25 × 4″·125, and consisted of decomposed granite; valves of *Spondylus latus* and *Serpula* were still attached. The other, also granite, though of a different character, weighed 3 lb. 12 oz., and measured 3″·6 × 5″·8 × 4″·5. Professor Bonney has furnished a description of the microscopic characters of the two boulders, which are possibly of Scandinavian origin. The author discusses the mode of transport to their present position, and favours the agency of floating ice.

3. "Coal: a new Explanation of its Formation; or the Phenomena of a New Fossil Plant considered with reference to the Origin, Composition, and Formation of Coal-beds." By W. S. Gresley, Esq., F.G.S.

The author argues that the brilliant black laminæ in coal and similar materials to those which form these laminæ, which are found in earthy coals, shales, and clays, point to the former existence of an aquatic plant, having the general shape of the modern *Platycerium alcicorne*, which grew *in situ*. He believes that much coal was formed by this aquatic "coal-plant," which grew amongst the mechanical sediments and the débris of the terrestrial vegetation which accumulated on the floors of sheets of water.

CORRESPONDENCE.

THE GREAT SUBMERGENCE "AGAIN."

Sir,—Has Mr. Dugald Bell adopted this title to show his surprise that the so-called "Submerger" has not been extinguished by his numerous writings on the subject?

Unless I have completely misunderstood the tenour of these communications, Mr. Bell formerly attached great importance to the supposed absence of high-level shelly Boulder-clay in the South of Scotland, as favouring his view that the Drift was due to *land-ice*: hence his strenuous endeavours to prove that such shelly beds did not

exist. These endeavours have proved futile, for, while a Commit
after sinking a well or enlarging an old one—I forget which-
Chapelhall, near Airdrie, have been enabled to say that they found
shells in the Drift where a previous observer had reported tl
presence, other observers have been discovering in Ayrshire la
deposits of Boulder-clay in which shells occur, often even possess
their epidermis. What adds pungency to the fact is, that these la
beds of Boulder-clay are exposed in numerous natural sections t
were open to the eyes of glacialists and others interested, who fai
to see that they contained marine shells—being perhaps stricl
with an ice-sheet blindness—while time and money were be
consumed in sinking wells elsewhere and finding nothing.

Now that large deposits of shelly Boulder-clay have been fo
to exist in Ayrshire at various heights, from sea-level up to 1062 f
my friend Mr. Bell is not inclined to attach so much importanc
their presence. In fact, he says, "the value of the Ayrshire secti
as proofs of submergence has yet to be determined. My own opini
frankly, is that it is *nil*."

As regards the suggestion that the Muirkirk beds have been l
down by a Frith of Clyde glacier, I can only point out that
hypothetical course of such a glacier does not correspond with t
of any map I have yet seen which professes to give the lines
glacial flow in Scotland. It is really too bad to ask geologist
grant phenomena as due to the devious courses of masses of land-
when such hypothetical courses have to be amended from day
day to fit in with the progress of discovery, and often involve
most surprising contradictions. T. Mellard Reade

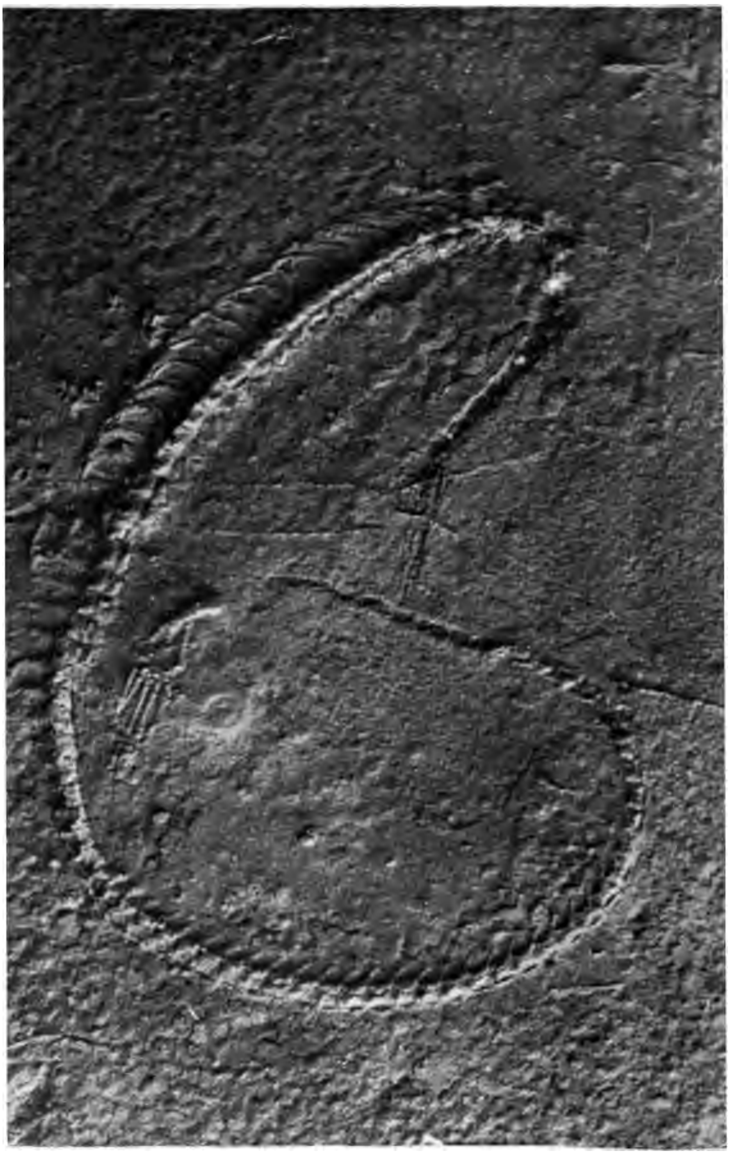
Park Corner, Blundellands,
February 3, 1897.

GENERAL SEQUENCE OF THE CARBONIFEROUS ROCKS.

Sir,—I feel deeply obliged to Mr. Etheridge for calling attent
to an omission in the Introduction to my Monograph on the Bri
Carboniferous lamellibranchs. I am sorry to say that in my ta
of the general sequence of Scottish Carboniferous rocks, the up
and middle groups of the Carboniferous Limestone series are
missing. How these lapses have come about I am unable to
for I have the most distinct recollection of inserting these gro
in their correct position in my MSS. Of course I am convicted
great carelessness in the reading of the proof, for which there
no excuse. Wheelton Hin

OBITUARY.

We regret to announce the deaths of Dr. Bernhard Lundgr
Professor of Geology in the University of Lund; and of Profes
Constantin Baron von Ettingshausen, the distinguished Palæobota
of Graz, Austria. We hope to give some account of these emin
men in the next number of the Magazine.



Stereosternum tumidum, Cope.

One half natural size.

Early Mesozoic: San Paulo, Brazil.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. IV.—APRIL, 1897.

ORIGINAL ARTICLES.

I.—On a New Specimen of the Mesosaurian Reptile, *Stereosternum tumidum*, from San Paulo, Brazil.

By Arthur Smith Woodward, F.L.S., F.G.S.,
Of the British Museum (Natural History).

(PLATE V.)

When in Rio de Janeiro last October, Dr. Orville A. Derby gave me for publication in the Geological Magazine the photograph of a fine new specimen of *Stereosternum tumidum*, reproduced in the accompanying Plate V. Like the type-specimens discovered by Dr. Derby, it was obtained from a light-grey limestone in a quarry on the estate of Senhor Antonio Machado de Campos, near the town of Limeira, in the State of San Paulo, Brazil. It is interesting as showing for the first time the general proportions of the trunk and tail of this strange extinct reptile; and it also permits the identification of another fossil from the same formation, now in the British Museum, which has hitherto escaped notice.

Stereosternum was originally described by Professor Cope in 1886[1] from an imperfect trunk and other fragments, which he could not assign to a definite systematic position, but believed to represent an aquatic reptile very similar to the small *Mesosaurus* from the Karoo Formation in South Africa. A year later he received from Dr. Derby a "nearly entire specimen," showing the head, neck, and fore-limbs, and this was the subject of a brief note in the "American Naturalist."[2] Professor Cope remarked:—"The neck is moderately elongate, and includes nine vertebræ besides the atlas. The vertebræ have robust transverse processes and slender cervical ribs. The skull is elongate and acuminate, and its bones are apparently fragile. Little of its structure can be made out. The teeth are slender, acute, and nearly straight, and are planted in (?) shallow alveoli." About the same time Dr. Baur[3] emphasized the importance of the structure of the tarsus, which exhibits a separate tarsal bone supporting each of the five digits, and made *Stereosternum* the type of a new reptilian order, termed Proganosauria. Other specimens wanting the greater part of the neck and tail were acquired by the British Museum, and these were noticed by Mr. Lydekker in 1889,[1] described by Professor Seeley in 1892.[2] It is now evident that the animal is related in some undetermined way to the ancestry of the Plesiosauria.

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[1] E. D. Cope, "A Contribution to the Vertebrate Palæontology of Brazil": Proc. Amer. Phil. Soc., vol. xxiii (1886), p. 7, pl. i.

[2] E. D. Cope, "The Carboniferous Genus *Stereosternum*": Amer. Nat., vol. xxi (1887), p. 1109.

[3] G. Baur, Zool. Anzeiger, 1886, p. 189, and "On the Phylogenetic Arrangement of the Sauropsida," Journ. Morphology, vol. i (1887), p. 103.

The new specimen of *Stereosternum* is shown in Pl. V of about half the natural size, and is curled up on the slab of limestone so that the end of the snout touches or overlaps the slender extremity of the tail. The head and neck are only indicated in impression; but it is clear that the head is of elongate-triangular form, with extremely delicate bones, and if the tip of the snout be truly represented by the end of the impression near the recurved tail, the length of the head is much less than that of the neck. Although the hindermost cervical vertebræ are proved to be short by one of the British Museum specimens, the impression seems to show that the centra of those nearer the head are considerably longer than deep. The skeleton is sharply bent and imperfect in the region of the pectoral arch; but the number of vertebræ between the neck and the sacrum must be about twenty, as already determined in a British Museum specimen, while the series of ribs is well shown on one side. The remains of the hind-limbs correspond with those of previous specimens. Assuming that an obscure fragment of the pelvis overlaps the transverse processes of the two hinder sacral vertebræ, the tail comprises not less than sixty vertebræ, of which at least the foremost seven bear robust transverse processes gradually diminishing in size backwards. The centra of the first twelve caudals are comparatively short and stout and exposed from above or below; the following thirty-five vertebræ, which are more elongated, are shown from the side, with the neural arch projecting within the curve of the tail, and the delicate loose chevrons lying parallel with the long axis of the centra on the outer side of the curve; the remaining vertebræ, to the number of about fourteen, are very slender and indicated only by an obscure impression. As a whole the tail is thus somewhat more than twice as long as the trunk, occupying slightly less than three-fifths of the entire length of the animal.

A detached tail of a precisely similar character, discovered in the same stratum and locality as the portions of trunk of *Stereosternum* in the British Museum (i.e. Ipanema), is interesting as showing not merely the skeleton but also an impression of the soft parts. This specimen (Brit. Mus. No. R. 538) is 0·13 m. in length and displays forty vertebræ in regular series, those towards the hinder extremity

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[1] R. Lydekker, "Catal. Foss. Rept. Brit. Mus.," pt. ii (1889), p. 302. Though the locality is not mentioned in the Catalogue, the dealer's labels state that these specimens were obtained from Ipanema.

[2] H. G. Seeley, "The Mesosauria of South Africa": Quart. Journ. Geol. Soc. vol. xlviii (1892), pp. 598–602, figs. 2–4.

only feebly ossified. All the centra are longer than deep and a little constricted; while some of them clearly exhibit the segmentation into two parts already noted in the anterior caudal vertebræ of previously described specimens. The backwardly inclined short neural spines are distinct, except in about six terminal vertebræ; and there are traces of the slender chevron bones as far as the thirteenth vertebra from the end. The soft tissues are indicated by a brown stain, of which the border is very sharply defined below, but less continuously observable above. At the thirtieth vertebra from the end the depth between the two borders of the stain is only 0·008 m., while at the terminal vertebra the depth is 0·005 m. Unless appearances are deceptive, and this is improbable, the tail of *Stereosternum* must thus have been an excessively slender appendage, without any dermal expansion at the end.

A fragmentary detached maxilla, from the same limestone and the same quarry as the type-specimens of *Stereosternum*, exhibits a few very long and slender teeth, like those already observed by Cope in this genus. This fossil is in the San Paulo Museum.

It is also interesting to add that Dr. Derby has obtained a typical Labyrinthodont tooth from a siliceous limestone at Conchas, which is almost certainly on the same horizon as that at Limeira. In fact, evidence is gradually accumulating to render it still more certain that the Karoo Series of South Africa is well represented by homotaxial deposits in the south of Brazil and in parts of the Argentine Republic.

EXPLANATION OF PLATE V.

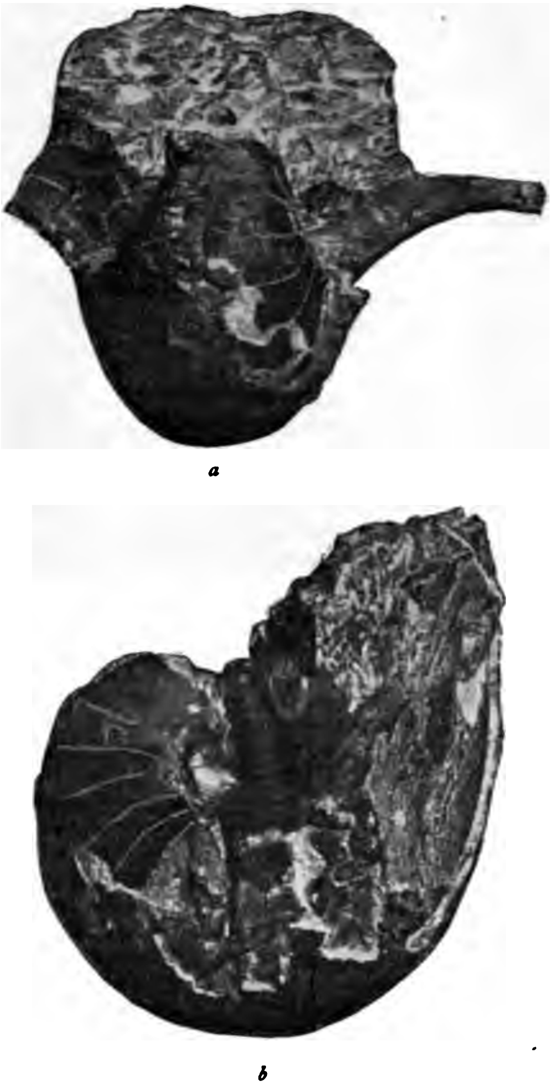
Stereosternum tumidum, Cope; photograph of skeleton, about one-half natural size. Early Mesozoic: near Limeira, San Paulo, Brazil. [Original in Museum of San Paulo, Brazil.]

II.—On a New Genus and Species of *Nautilus*-like Shell (*Acanthonautilus bispinosus*) from the Carboniferous Limestone of Ireland.

By Arthur H. Foord, Ph.D., F.G.S.

(PLATE VI.)

THE shell to which I have given the above name is at present unique. It was found, a few years ago, in a quarry at Clane, in the county of Kildare, where I had for some time been in search of Cephalopod shells. It was associated with characteristic species of Carboniferous Limestone fossils, among which the following Nautiloid shells may be mentioned, viz. *Solenocheilus dorsalis*, Phil., sp., *Asymptoceras cyclostomus*, Phil., sp., *A. Foordi*, Hyatt, and an undescribed species allied to the last-named one. The marginal spines, at first obscurely seen in the matrix, at once attracted attention; and although one was broken off and lost in the quarry débris, the other was fortunately found in the fragment of rock struck off from the shell, and was then carefully developed and attached to the latter. Naturally very diligent search has been made since its discovery, and a sharp look-out kept for any further specimens of this interesting species, but so far without any result.



Acanthonautilus bispinosus, A. H. Foord.
Carboniferous Limestone: Clane, Co. Kildare, Ireland.

a. Front view, showing spines and sutures. } $\frac{2}{3}$ nat. size.
b. Side view, showing sutures and general outline. }

Description.—The shell is of medium size, *Nautilus*-like in its general habit, somewhat globose, and expanding rapidly. It consists of about two or two and a half volutions, the inner ones of which are concealed by the lateral expansion of the shell. The peripheral area is broadly rounded and somewhat flattened on the body-chamber, especially towards the aperture, in the adult, but more narrowly and evenly rounded in the younger stages of growth. The umbilicus is rather large and very distinctly funnel-shaped. It is provided with a thick and very conspicuous rim, which is produced into long, flat, hollow, spine-like processes, projecting almost at right angles to the longitudinal axis of the shell on each side of it. The spines, whose flatness is nearly on the same plane as the surface of the peripheral area, are greatly expanded at their base, but become rapidly narrow towards their distal end, their basal portion merging with a slight concavity in the general surface of the abdominal part of the shell on the outer side, while on the inner side they are continuous with the umbilicus. The spines are met anteriorly by the border of the mouth; posteriorly by the rim of the umbilicus, from which they proceed on that side. They thus make here a curve on their inner edge which is directed outward and slightly downward at the same time. The direction of the spines with reference to the longitudinal axis of the shell is nearly that of a right angle, with a perceptible inclination downwards, that is, towards the septate part of the shell.

Both the spines are imperfect, one having been broken off near the base, the other at a distance of about 50 mm. therefrom. The former is seen to begin with two diverging folds of the shell, originating as above described. These make an angle, of which the apex is formed by the rim of the umbilicus. The two folds rapidly approach each other, till, as the more perfect spine shows, they run nearly parallel, forming a flattened tube up to the end of the spine, as far as it is preserved. The flattening may be partly due to pressure in the rock, but, on the other hand, the pinched look of the two folds of the shell near the base of the spine, where there is no evidence of crushing, is already so marked as to contradict the supposition of an artificial flattening of the spine in a great measure.

The outline of the aperture, which can be accurately traced, is curved gently forward on either side, and forms in the centre a broad and shallow hyponomic sinus.

The sutures, of which only five are visible, are moderately distant, the last two somewhat closer than the rest. The septa have been completely destroyed by the deposition of crystalline calcite in the chambers, the removal of a great part of which revealed no traces of them; nor were any remains of the siphuncle found.

The test is quite smooth, only slightly marked lines of growth occurring on the body-chamber. It is about 1 mm. in thickness.

The greatest diameter of the shell is 16 cm., measured from the outer margin of the aperture to a point diametrically opposite to this. The transverse diameter, measured across the shell from the base of one spine to the base of the other, is 13·5 cm. The distance between the septa, measured from the posterior to the anterior, is 14 mm., 17 mm., 20 mm., 13 mm., and 12 mm.

Remarks.—The presence of the long, marginal spines dissociates this form from any other Nautiloid shell known to me, and dictates its generic appellation, while it also constitutes its chief specific character.

In seeking for species related to the present one in their general form, those comprised under the genus *Solenocheilus* (Meek and Worthen), and its congeners *Lophoceras* (Hyatt) and *Asymptoceras* (Ryckholt, emend. Hyatt), suggest themselves as being the nearest to it. In some of these species there arise from the angles of the margin of the aperture spout-like projections which at first sight might be taken, in their imperfect condition, for the stumps of spines similar to those of the present species. Such appendages are seen in a species described by Meek and Worthen[1] under the name of *Nautilus* (*Solenocheilus*) *Leidyi* (*Lophoceras Leidyi* of Hyatt).[2] This species (which was found in the Keokuk beds at Warsaw, Illinois), consisting only of the body-chamber, has on each side of the shell, at the junction of the lateral margin and the umbilical wall, a "kind of pinched prominence," which "seems even to have projected outward somewhat as in *Argonauta gondola* of Adams,[3] though probably not to the same extent." It is clear that the spout-like projections here described correspond in no way, except in their position, with the long, flat spines of *Acanthonautilus bispinosus*. The former may, like the hyponomic sinus of the aperture, have given exit to some of the tentacular appendages; the latter, not being channelled, could have served no such purpose. What purpose they did serve it is difficult to conceive, but it is safe to say that they furnished, in a measure, a safeguard against attack.

The thickened rim of the umbilicus is paralleled only in one other Nautiloid, so far as I know, viz. the *Nautilus terebratus* of Dumortier[4] from the Upper Lias of La Verpillière (Isère), France, and of Lincoln. The rim of the umbilicus in this species ends in a slightly prominent lateral angle.

As the spines in the present species are perfectly symmetrical, it is obvious that they were secreted by symmetrical organs. What these organs were, must be matter of pure conjecture. It cannot be supposed that they were of the nature of the tentacles of the *Nautilus* or of any of the cuttle-fish tribe now existing. There is reason to suppose, however, from their hollow structure that the spines were secreted from the inside.

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[1] Geol. Surv. Illinois, V, Geol. and Palæont., 1873, p. 524, pl. xviii, figs. 2, 2*a*.

[2] Geol. Surv. Texas, Fourth Annual Report, 1892 (1893)—Carboniferous Cephalopods (second paper), p. 466.

[3] For a figure of this see Lovell Reeve in Conch. Iconica, vol. xii, 1860, pl. iv, fig. 3. I have not access to the original source of the species.

[4] Études Paléontologiques sur les Dépôts Jurassiques du Bassin du Rhône, pt. iv (Lias Supérieur); see also Catalogue of Fossil Cephalopoda in the British Museum, pt. ii, 1891, p. 204, ff. 36, 37.

III.—NOTES ON A COLLECTION OF ROCKS FROM THE TONGA ISLANDS.

By J. J. H. TEALL, F.R.S., and E. T. NEWTON, F.R.S.

(Communicated by permission of the Director-General of the Geological Survey.)

A SMALL series of rocks collected at several localities in the Tonga Islands by Lieutenant J. A. Waugh, R.N., during the voyage of the "Penguin" in 1895, has been forwarded to the Geological Survey for examination, by Admiral Wharton, R.N., F.R.S., Hydrographer to the Admiralty. As in some particulars these rocks supplement those already described by Mr. A. Harker (GEOL. MAG. 1891, p. 250), from the same group of islands, it seems desirable that a short account of them should be placed on record.

The specimens first to be noticed were obtained from Mango Island, one of the most central of the Tonga or Friendly Islands, where some of Mr. Harker's rocks were also collected. It appears from the information supplied with the specimens, that at the south-eastern extremity of Mango Island there is a series of small cliffs, and from these, at a height of six feet above high-water, three types of rock were collected.

No. IA (F. 311). This is a fine-grained and bright-green, indurated mud, which does not easily disintegrate in water. Under the microscope the rock is seen to be largely composed of irregular, and often angular, fragments surrounded by narrow, deep-green borders. It is possible that these fragments may represent lapilli of volcanic glass, and that the green substance may be of the nature of palagonite; but the evidence for this is by no means satisfactory.

No. IB. Fragments of light-yellowish and reddish decomposed andesitic tuffs.

No. IC. This is a creamy-white, fine-grained, and chalky-looking rock, similar in appearance to that noticed by Mr. Harker (loc. cit., p. 255); it is very calcareous, and when examined as powder, in water, under the microscope, is found to contain numerous sponge spicules; but the greater part of the rock is made up of amorphous calcareous particles.

No. II. This specimen was likewise obtained from Mango Island; but from its highest point, 139 feet above high-water; it is a coarse, decomposed, andesitic agglomerate.

Both the green mud (IA) and the white rock (IC) appear to have been deposited under water, and although they are still only six feet above high-water, it is probable that they have been upheaved since their deposition.

No. III (F. 312). Two specimens from Tanoa Island, north-east of Mango, were obtained at 20 feet above high-water. One of these is a pale-brown andesitic tuff, and a microscopic section of it shows crystals of green augite and felspar, but evidently mixed with "coral sand," for it includes many fragments of organisms, such as corals, sponge spicules, foraminifera of several kinds, and possibly Radiolaria. Among the foraminifera, *Globigerina* seems to be the most abundant; but the first to attract attention, even in a hand-specimen, are some spherical forms (a large one is 6 mm. in diameter) which, on comparison with examples of *Orbulina universa*, kindly lent by Dr. G. J. Hinde, leave no doubt as to their belonging to that species.

The shells of the foraminifera are now represented by a colourless isotropic substance, presumably silica, the whole of the carbonate of lime having been removed.

No. IV. From the centre of Telekitonga Island, one of the Otu Tolu group, rounded lumps of pumice, which float in water, were collected at about 10 feet above high-water. These are composed of crystals of hypersthene, augite, and felspar in a highly vesicular, nearly colourless glass. This is the type of rock so widely distributed throughout the Pacific region.

No. V (F. 313). This is a rather coarse and partly indurated "coral sand" from Lalona Island, another of the Otu Tolu group; it is said to be a few feet above high-water, and a similar rock occurs round the shore-line of all four of the islands forming this group. It is a fairly hard rock containing rolled fragments of corals, nullipores, and shells of small molluscs. A few examples of the large stellate foraminifer, *Tinoporus baculatus*, may be seen. This Rhizopod is common in the South Pacific, and occurs in some abundance in No. VIII specimen. Professor Sollas found that *Tinoporus* and *Orbitolites* form the greater part of the "sand" which fills many of the interstices of the coral reef at Funafuti (see *Nature*, Feb. 18, 1897).

No VI is a pumice of hypersthene andesite similar to No. IV, from the middle of this island of Lalona, at about 10 feet above high-water.

No. VII (F. 314). A consolidated "coral sand" similar to, but finer than, No. V, from the eastern side of Lifuka Island, one of the Haapai group, just above high-water. Rolled fragments of corals, nullipores, etc., make up the mass of this rock, which, however, is remarkable for the great number of the foraminifer, *Tinoporus baculatus*, it contains, accompanied by the very similar, but spineless form known as *Gypsina*.

No. VIII (F. 315). Dark-brown sandy tuff, composed of andesitic lapilli and broken crystals of hypersthene, augite, and felspar, from Mo'unga'one Island, Haapai group, 30 feet above high-water.

No. IX is from the same island, but at the coast-line and from rocks 12 feet high. This is a cavernous mass of "coral rock," very dense and much weathered, consisting almost entirely of indurated coral, and may well have formed part of a coral reef. If the mass of the rock is similar to this specimen, it is probable that it is an elevated coral reef.

No. X (F. 316) is a portion of the beach rock of Lofanga, another of the Haapai Islands, and is said to have dead corals still adhering to it. This, again, would seem to indicate an elevation of the shore. The rock is an andesitic tuff; both lapilli and crystals are surrounded by a thin incrustation of calcite, which acts as cement and serves to bind the particles together.

It is interesting to note that even in so small a series of specimens as those above noticed, there is evidence of some of thes Islands having been upheaved, for although the consolidate sand" may have been thrown up to its present level by and have been indurated very recently in that position, yet highly probable that some of the rocks (Ia, Ic, III, and IX and X) have been formed under water and afterwards

Mr. Harker, in concluding his paper, speaks of the poss some of the rocks of the Tonga Islands proving even be of Tertiary age. None of the specimens we have e give any evidence of such an antiquity.

IV.—On the Erratic Boulders and Foreign Stones Drift Deposits of Eastern England, and their Le

By Sir Henry H. Howorth, K.C.I.E.; M.P., F.R.S., F.G.

(*Concluded from the March Number*, p. 130.)

FOLLOWING in the wake of that admirable institution the Committee of the British Association, whose work ough been done by the Geological Surveyors, we may divide the from which the foreign boulders (that is, boulders extraneo immediate district) have come to Eastern England into four, Charnwood Forest, the Hills of Derbyshire, Durham and Cl and lastly Norway.

First, in regard to Charnwood Forest. Nearly all the which have travelled thence have travelled to the south-we south-east, or east, a small number only having been foun north of the parent rock.

This district, where a considerable mass of crystalline exposed, is particularly fitted to test the problem of local gl South-Eastern England. It is very curious that, with the e of a very small patch of smoothed rock found by Mr. Harr a trace of glacial action can be found here. Upon this Carvill Lewis is emphatic, and his conclusion is supported co by two such good observers as Professor Bonney and Mr. Hil also support Mr. Lewis in attributing to other than glaci the local patch referred to by Mr. Harrison, which it remembered is only about two yards long. Professor Carvil an extreme glacial champion, says of it that it is not an of true glacial striæ, but is a very local smoothing due to gravel or possibly an iceberg ("Glacial Geology o Britain," p. 61).

This conclusion is very important, for several reasons. were no ice on the high ground of Charnwood Forest, which 800 feet high, how can we believe in its existence on the shire and Norfolk Wolds, which are in the same latit very much lower? This is another argument to add I used in a former paper with regard to the impossi understanding the former existence of local glaciers o Downs. But a more important fact remains. If there traces of glaciation in the mountainous region of crystalline rocks of Charnwood, where such traces would be so easily preserved, proving, in fact, that no ice existed there or passed over the district, how can we account for the distribution of the Charnwood Forest boulders by ice at all? This, in itself, conclusive argument does not stand alone. If the glaciers were local, how comes it that nearly all the erratics from this district are found to the south of their place of origin and are not distributed all round it in an equal degree? If the ice came in from the north, how could any of the boulders travel north at all in the face of it? Again, inasmuch as these boulders from Charnwood Forest are often mixed with those from Derbyshire and elsewhere in the beds where they are found, how can ice have brought any of the stones? It could not bring stones from the north, carry them across the Charnwood Forest area, and mix them with Charnwood Forest stones from Mount Sorrel and elsewhere, without leaving substantial evidences of its passage in Charnwood Forest itself.

Putting Charnwood Forest aside, we have to explain how the Mountain Limestone and Millstone Grit of Derbyshire, the Carboniferous rocks of Durham, the basaltic rocks from the dykes of Durham and Cleveland, come to be mixed as they are mixed in almost every part of Eastern England where so-called glacial beds occur. How could the ice from the north-west come down to Finchley and to Norfolk without stopping the passage of the ice from Durham across the same path? I confess I do not know; nor do I know how, when this ice got to its destination, it could begin mixing the ingredients of the chalky clay, which came from different parts of heaven, and redistribute them as we see them distributed. The theory is too fantastic and ridiculous for words, and the fact that it has so many adherents is a continual reproach to nineteenth-century science. I have not yet done. I have referred above to the Norwegian boulders. Upon them I had a polemic in these pages some time ago with Mr. Harker and others. Feeling it to be impossible to attribute their portage to ice in any form, I ventured to suggest as a possible alternative that they had been brought to where they are found as ballast, or they might possibly be Scotch rocks. In regard to the former alternative, I found after I had written what I did that Mr. Clement Reid, a very careful observer, but with many of whose inferences I cannot agree, had warned geologists of the great quantity of such ballast that had been imported into Eastern England from Russia and Norway, and had been distributed over its fields; while Professor Hughes had pointed out several cases of wrecked ships on the Eastern coasts, where large numbers of Norwegian boulders had found their way to English beaches.

I am bound to say that, while giving due weight to these considerations, the reports of the Boulder Committee of the British Association, and especially Mr. Sheppard's recent researches, make it impossible for me to maintain any longer the extreme position I took up in my controversy. I am convinced now that the rocks are certainly Norwegian, and that these Norwegian boulders have actually been found in undisturbed Boulder-clay and in its associated beds, and that, therefore, if they are to be explained, some other explanation than the one I gave must be forthcoming. My present object is not to point out what that cause was, but to show that it was not, and could not be, ice. Those who have invoked an ice-sheet in the North Sea, and have thus explained the portage of the Norwegian stones, so far as I know have done so, firstly, in order to account for those stones; secondly, to account for the diversion of the Durham drift to the south, it being thought that only a barrier of ice in the North Sea would have diverted the supposed ice of the Tees, with its burden, to the southward; and thirdly, to account for the peculiar glaciation of the Shetlands. This theory of the North Sea ice-sheet has had some vicissitudes in its history, and I have had a good deal to say to it on other occasions. At first it was made to occupy the whole North Sea area, extending as far as the five-hundred fathom line. Then Professor James Geikie went to the Faroes, and found that those islands had had a local set of glaciers of their own, so that it was impossible to believe that the great ice-sheet had extended over them. It was still, however, maintained to have existed on a great scale, and made to overwhelm the Shetlands, although not a trace of one undoubted Norwegian boulder had ever been found in those islands; while Mr. Milne Home, a most experienced Glacial geologist, and Chairman of the Scotch Boulder Committee, continually pressed the conclusion, as it seems to me unanswerably, against the Geological Surveyors that the striæ pointed in a direction inconsistent with such an ice-sheet. Then came the observations on the Lofoden Islands, showing that they are pinnacled and unweathered, and therefore that no ice-sheet could ever have overrun them; then came Pettersen's famous examination of the question from the Norwegian side, showing that the ice from Western Norway, far from having traversed the North Sea, had not even reached the line of islets that run down that coast. This conclusion, which I have enlarged upon in my "Glacial Nightmare," has been extended to South-Western Norway by De Geers, whose work is much relied upon by Dr. James Geikie, and who says that in the second Ice Age (that is, with him, the great one) it is improbable that the land-ice traversed the deep channel which now bounds the coast of South-Western Norway.

Dr. James Geikie, who was with Croll the joint prophet of the original North Sea monster, has, in the last edition of his "Ice Age," made a great concession to the enemy on this question. Speaking of the glaciation of Scandinavia, he now says: "Along the west of Norway the great fiords were at the same time occupied by glaciers, *which do not appear to have extended beyond the general coast-line, but carved their icebergs there*" ("Great Ice Age," p. 46. The italics are mine). For this conclusion the authority of Pettersen and De Geers is quoted, and it is a very just one. How it is possible in any way to reconcile it with Professor Geikie's two maps of Europe at the period of maximum glaciation and the third Glacial epoch respectively, and in the same book, I cannot understand; and it is inexplicable how, after such a statement, these most misleading maps should have been retained. If it means anything it means that there could be no ice-sheet shed into the North Sea at all from Western Norway, since the ice there did not extend beyond the Norwegian coast; nor, in view of this confession, can I understand such sentences as the following, approvingly quoted from Croll: "The Scottish *mer de glace* must have advanced over the bed of the North Sea to coalesce with the great ice-sheet which at the same time crept out from Norway." Dr. Geikie adopts this sentence, and then goes on to say: "This acute inference was subsequently proved to be correct by the observations of Messrs. Peach and Horne, who showed that the Orkney and Shetland Islands had been overwhelmed by the United Scoto-Scandinavian *mer de glace*" ("Great Ice Age," new edition, p. 85). Again, "during the formation of the basement clay [of Holderness] the bed of the North Sea was occupied by a great *mer de glace*, which invaded Holderness from the north-east" (id., p. 363). Again, he speaks of "the advent of the North Sea ice-sheet, which as it passed to the south-west became confluent with that broad stream of ice underneath which the Lower Boulder-clay of Yorkshire, etc., was accumulated" (id., p. 375). I will not refer again to Mr. Milne Home's acute analysis and criticism of the case for the glaciation of the Shetlands by ice coming from the north-east, as supposed to be proved by striæ coming from the north-west, but will content myself with asking how Professor Geikie, having destroyed his Norwegian ice-sheet on page 468 of his book, came to retain these extraordinary instances of contradiction with himself on pp. 85, 363, and 375. I know of no parallel to this so complete as the practice of a Scotch parson in Manchester who, having two congregations which do not agree with each other, devotes the afternoon sermon to confuting the sermon of the morning!

With the disappearance of this Norwegian ice-sheet disappear the conclusions about the Scotch ice being banked up and thrust back upon Scotland by the pressure of the great monster, and disappears also the extraordinary notion, originated, I believe, by Mr. Jack, that the so-called Tees Glacier was turned aside and had to make an elbow, and then proceeded leisurely to the south in consequence of having met with an impassable wall of ice in the North Sea. Some other cause, less fantastic and less inspired by poetry, will clearly have to be forthcoming if we are to account for the difficulties supposed to exist in either area. We still have left for consideration the Norwegian stones which occur in the maritime districts of Yorkshire, Lincolnshire, and Norfolk, and the ice-sheet which is supposed to have brought them. Let us see what is really meant by this egregious postulate. None of the Norwegian stones in question have been traced to Western Norway nor to the Dovrefelds. They have all been traced to the comparatively low-lying western border-lands of the Christiania Fjord. We are, then, to believe that at a time when the great Norwegian range of mountains could only drive the ice on its flanks and on its shoulders down the fjords as far as the sea, and no further, the ice on the low-lying lands bordering the Christiania inlet was able to convey its load of stones right round the Naze of Norway and then across the North Sea to Yorkshire and to Norfolk! How is this to be accounted for by any sane theory? Suppose we postulate the possibility of such an ice-river as this, how was it to travel, not along a valley, where the line of least resistance would enable it to flow, and which was perfectly open to it, namely, the hollow trough running up the coast of Norway, but right across several valleys and downs in the bottom of the North Sea, that is, right across the line of least resistance. Not only must it have moved uphill and downhill, but also adopted in addition a most sinuous and extraordinary course, apparently uncontrolled by the contour of its bed, and for no reason under heaven except to supply the orthodox geologists with an opportunity to test the extreme gullibility of geological mankind in the nineteenth century.

Again, if such an ice-stream adopted such a course it must have had a tremendous push behind it, and this means that the slope of its upper surface must have been at a very considerable angle, and if so the ice must have been of portentous depth at the initial stages of the journey. This syllogistic chain of argument would be conceded, I presume, by everybody, even by the orthodox geologist. If this were the case, how were the stones ever got at by the ice at all, for the whole country must have been smothered in ice, and especially the district of Laurvig. There could be no "Nunatakkar" to supply the stones in a district so low as this if we are to have an ice-river flowing thence to England. Again, we would point out De Geers' map of the "End Morainen," or terminal moraines, of the Norwegian Mountains (see Deutsches Geol. Gesell., vol. xxxvii, Tab. xii) in this very district of Laurvig, and ask how they are to be explained at all if an ice-sheet ever came down the Christiania Fjord. Again, if this Laurvig ice-river came to England with its stones, how was it possible for the postulated ice-sheet from Westmoreland and North Lancashire to get out to sea for twenty miles, and leave there its burden of Shap Fell stones which have been dredged in numbers at that distance from our coast. Did the two monsters embrace in the middle of the North Sea and then change places, as we do in a quadrille, and dance a jig together in Holderness?

If we are to credit the account of Mr. Plant, who describes with some deliberation the finding of Norwegian boulders at Leicester, and another account which refers to a piece of rhomb-porphyr found at Cambridge, the Norwegian glacier must have extended far into England, if it came here at all. If it came so far, how was the Durham glacier to cut right across it, in order to bring its load of stones down to Essex?

And when these several glaciers all arrived, how were they to mix their various loads, here with gravel, there with sand, and there with clay, without mingling the whole of these deposits into a common hotchpotch? And how, having arrived, were they to collect the débris from the low-lying Fen country, over which the ice would be passing fathoms deep?

And where are the terminal moraines they left? Even if, as some allege, it is not reasonable to expect such terminal moraines in the case of widespreading and all-overwhelming ice-sheets—although much is made of such supposed terminal moraines in Germany and America—where are the terminal moraines of the glaciers which are supposed to have come from Durham and from Derbyshire, and from many districts nearer still? Where are the concentric mounds? Where is there a trace of true moraine stuff—that incongruous mixture of sand, clay, gravel, and stones—to be found among these sorted beds? These beds are not heterogeneous, but are sorted in regard to contents, and sorted also in so many places in regard to locality, and spread, not as glaciers spread their burdens, which throw them down at the end of their journey in great mounds and ramparts, but distributed like a warm and beneficent blanket over the wounded and torn surface of the country, all smoothed down to levels of beautiful curvature, and as unlike the kind of thing at the mouths of Norwegian and Swiss mountain valleys as a heretic is unlike a geologist.

Lastly, to revert to an argument already used in former papers. Having come to Eastern England with their foreign stones, how did these glaciers proceed to gather from the east and from the west Chalk and Oolite and Lias fragments, and to mix them with their own burden of stones, to sort them so that they got smaller as we go farther south, and to imbed them here in gravel, there in clay, there, again, in sand, and then to redistribute them. To appeal to ice as the performer of this kind of legerdemain is to do in effect what the peasants in outlandish places still do, and to call in Robin Hood, or Mr. Labouchere, or the Devil, or anybody else that seems likely to have done otherwise impossible things. Either the possibility or the probability should be proved, or this kind of speculation should be banished from serious scientific works and memoirs, and especially from memoirs which have an official sanction.

I have tried to show that the drift beds of Eastern England in every feature known to myself, stand at the antipodes of glacial deposits, and yet the same cry will go on until this generation is extinct. It is very difficult even for Africans to break their fetishes. How much more difficult for official and other influential geologists to tell the world they have been leading them a "wild-goose chase" for fifty years. If they are not likely to listen to the Philistine from the other side of the hedge, they might, at least, listen to one prophet, whose advocacy of the Glacial theory has been otherwise extravagant. Professor Carvill Lewis, speaking of the area which has alone occupied us in these papers so far, and which on his maps he entirely excludes from his Glacial area, says: "I think that by far the larger part of England was not covered by land-ice" ("Glacial Geology of Great Britain," p. 20).

Speaking specifically of the counties of Lincolnshire, Norfolk, Suffolk, Cambridge, Nottingham, Stafford, Warwick, etc., he says of the ice-sheet or great glacier, which is supposed to have covered them: "It would be a curious kind of glacier which could at once carry boulders from the south as well as from the north, from the west as well as from the east, mixing them all in one deposit; and which was able neither to make moraines, nor to striate rock surfaces, nor to smooth projecting crags" (id., p. 55). I quote this, not because I am in general agreement with Professor Carvill Lewis,[1] for I am not, but because he being considered an almost inspired prophet among the Neo-Glacialists, it is useful to use one of his bomb-shells against them.

Thus I have, so far as I can see, shown that it is impossible to attribute the drift deposits of the Eastern Counties of England or their contents to either ice-sheets or glaciers.

Note.—Referring to note on p. 128, March, 1897, I am reminded that hollows in the floor of the glacier could clearly only be made if the glacier remained stationary.—EDIT.

V.—ON THE SUBDIVISIONS OF THE CARBONIFEROUS SERIES IN GREAT BRITAIN, AND THE TRUE POSITION OF THE BEDS MAPPED AS THE YOREDALE SERIES.[2]

By WHEELTON HIND, M.D., B.Sc.Lond., F.R.C.S., F.G.S.

THE correlation of the various series of Carboniferous rocks which occur in different districts of Great Britain according to the fourfold subdivision proposed by the late Professor Phillips, has always presented great difficulties, on account of the marked changes in sequence, thickness, and lithological character which occur in districts only a few miles apart. The consideration of this difficulty was the subject of a special Sub-Committee of the International Geological Congress of 1888. The Report, however, indicated only a difference of opinion, and consisted chiefly in a series of typical sections showing the local development of Carboniferous rocks, and the schemes of classification proposed by various members of the Sub-Committee.

Of late, the officers of the Geological Survey have, to a large extent, dispensed with the term Yoredale Series, and have substituted the title *Carboniferous Limestone Series*, to denote the whole of the beds from the base of the Carboniferous to the bottom of the Millstone Grit Series in England. But this term was used by Professor Phillips to include, not only these beds, but the Millstone Grit as well ("Geol. Yorks.," pt. ii, p. 11).

Unfortunately, the term Carboniferous Limestone Series has been applied, not only to the alternating series of sandstones, limestones, and shales which are characteristic of the northern representatives of the Carboniferous Series, but has (following Professor Phillips) been used to denote the massif of the Carboniferous Limestone, and the series of shales and sandstones above which occur in South-West Yorkshire, Lancashire, Cheshire, North Staffordshire, and Derbyshire. For, although this series of shales and sandstones appears to occupy an analogous position between the thickest bed of limestone in North-West Yorkshire or the massif of limestone in Derbyshire, and the base of the Millstone Grits, respectively, the intervening series in each case differs essentially, both lithologically and palæontologically; and in my opinion these two series, which have been so long confounded together under one common term, are totally distinct, and really form the key to the Carboniferous sequence in Great Britain.

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[1] By some lapse of memory I find I called Professor Carvill Lewis "Carvell Williams" in two places in my previous paper, GEOL. MAG., December, 1896, p. 537.—H. H. H.

[2] Read before the Geological Society of London, December 16, 1896.

It was unfortunate that Professor Phillips adopted the term Yoredale Series for one of the main subdivisions of the Carboniferous system, although the term was undoubtedly applicable for a local series of rocks in Wensleydale, etc., which exhibited a gradual but marked change in lithological type from those immediately below them; although there is no doubt that he was aware that the Yoredale Series[1] was only the local equivalent of the upper part of the Carboniferous Limestone, yet he insisted on correlating the beds with those which, in a different area, were undoubtedly above the massif of limestone. A single quotation[2] will suffice to show Professor Phillips' view as to the relations between the massif of limestone and his Yoredale Series: "The great limestone series which at Greenhow Hill is one mass, admits between some of its upper members partings which are thin at Grassington and Kettlewell, but towards the W., N.W., and N. augment in thickness and assume new characters." This statement is important, because it is based on the stratigraphical facts; and it is this splitting up of the upper part of the mass of limestone by beds of shale, with intercalations of sandstone further north, which gives rise to the succession of beds in Wensleydale, where they have received the name Yoredale Series; the term should, however, only be retained for these local beds, because they are typical only of a limited area.

But at the same time it follows that it is erroneous to regard the Yoredale beds as superimposed upon the Carboniferous Limestone, for they are, unmistakably, the direct equivalents of each other; and that such is the case can be shown on the strongest palæontographical and stratigraphical evidence. In the briefest possible way, I will indicate the evidence from the ground itself. One great but important objection to the use of the term Yoredale Series in any other but a local sense, is the uncertain and arbitrary line adopted as its base. In North-West Yorkshire the Great Scar Limestone was taken as the upper limit of the Carboniferous Limestone; but this limestone, although in Wensleydale somewhat massive, when traced north splits up and undergoes marked lithological changes, and becomes the Melmerby Scar Series. The Hardraw Scar Limestone, which is the bed of limestone next above the Great Scar Limestone in Wensleydale, when traced south, gradually, by a thinning out of the intervening beds, approaches and becomes one with the massif below, so that the bottom bed of one subdivision of rocks becomes one with that next below it; and, on the other hand, in the Ingleboro area, other thin limestones, with intercalated beds of shale and sandstone thinning out south, named the Gayle and Hawes Limestones, appear between the Hardraw and Great Scar Limestones, so that it cannot be said that the line chosen was that at which the massif of limestone ceased to split up. Traced northward, the Great Scar Limestone becomes separated into distinct beds, by wedges of sandstones and shales, so that, although in Wensleydale only from eight to ten separate beds of limestone are recognized, at Alston Moor there are twelve limestones, and in Northumberland Westgarth-Foster recognized nineteen. Indeed, it may be laid down as a marked fact that, as the Carboniferous beds are traced from south to north, the organic deposits become thinner, intermittent, and separated by sedimentary beds which thicken in the same direction, and thus, by degrees, the series of Carboniferous rocks so typical of Derbyshire passes gradually into that series which obtains in Northumberland and Scotland. Calcareous deposits are essentially different in origin from those of sandstone, clays, and similar materials; for they are almost entirely derived from the remains of living organisms, and not from terrestrial denudation. Sandstones and clays, on the other hand, owe their origin to the waste material and detritus removed from land-surfaces by the action of water, chiefly in the form of rivers, and consequently denote a deposit in comparatively shallow water, laid down at no great distance from shore.

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[1] "Geol. Yorks.," pt. ii, pp. 19, 27, 32, 33, 34, and 61, pl. xxiii, Nos. 9 and 10; pl. xxiv, sections 3 and 24.

[2] p. 32.

In Derbyshire and North Staffordshire the Carboniferous Limestone is practically all in one mass, containing, however, several beds of Toadstone;[1] although there may occur thin shaly partings of a few inches in thickness, a good example of which is to be seen in the quarry opposite the High Tor at Matlock, and in Combsdale, where, in the upper part of the limestone near Matlock Bath, a thin coal, with its underclay, was found.

Above the main mass of limestone there may occur, locally, a few feet of thin limestones, alternating with shales and limestones, as at Butterton Moor, North Staffordshire; but no marked beds of limestones occur in the 2000–3000 feet of shales and sandstones which overlie the limestone.

Towards the top of the limestone, and occupying the base of the escarpment at Castleton, whence it can be traced for many miles along the same horizon, is a well-marked sea-beach, with rolled shells and fragments, and an occasional quartz pebble. This was discovered by Messrs. Barnes and Holroyd, who have described the beds in a recent paper read before the Manchester Geological Society. This beach deposit came on gradually, reached a maximum, and then declined, as shown by the quantities of shell fragments and rolled fossils it contains. It does not form the extreme top of the limestone, but is itself overlain by a few yards of massive limestone. All the famous fossiliferous localities of Derbyshire and North Staffordshire appear to occur at horizons just immediately above or below this beach.

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[1] See Arnold-Bemrose, Quart. Journ. Geol. Soc., vol. L, 1894, pp. 603–644.

The next great exposure of Carboniferous Limestone north of Derbyshire is at Clitheroe, and here there is a fine sequence to be seen in the western escarpment of Pendle Hill, at the base of which the limestone is exposed. The top of the hill is formed of grit, formerly called the Yoredale Grit, now recognized by the Geological Survey as a Millstone Grit, older than the Kinderscout, or fourth grit. It is estimated that 2500 feet of shaly beds intervene between the Mountain Limestone at the base, and a series called the Pendleside Limestone of 350 feet in thickness, which occurs just below a bed of grit called the Lower Yoredale Grit. This bed is not very constant in extent, but whenever it is present it always occupies the same horizon. Mr. Tiddeman describes it in the Memoir on the Burnley Coalfield as follows: "It consists of grits and sandstones, with shales and ironstones interbedded. . . . . In appearance they (the sandstones) are often not unlike the Gannister rock of the Lower Coal-measures, though not containing the root beds of that rock; plant-remains, however, are of common occurrence in them."

The Lower Yoredale Grit is separated by about 200 feet of shales from the Upper Yoredale Grit, which caps Pendle Hill. These are known as the *Bowland Shales*, and are important as containing a molluscan fauna of Lower Coal-measure facies—*Posidonia*,[1] *Orthoceras*, and *Goniatites*. From the lists of fossils given at the end of the Burnley Memoir by Mr. Etheridge, it is conclusively shown that the majority of the species found in the Pendleside limestones is common to it and the Carboniferous Limestone below, although the beds are separated by 2500 feet of strata which do not contain a similar fauna.

The Upper Yoredale Grit of Pendle is supposed to be the equivalent of Farey's Shale Grit of Derbyshire, and with very good reason, on account of the relation which both have to the fourth and fifth, or Kinderscout grits. The upper and lower Yoredale Grits are now known as the Pendleside Grits, and these constitute the base of the Millstone Grit Series of the Geological Survey. From the top of Pendle Hill there is a regular sequence to the Coal-measures of the Burnley Coalfield, and the fourth grit forms a feature of the ground from Hoolster Hill by Mellor Walley Nab and Wiswell Moor to the Nick of Pendle. Succeeding the fourth grit are the Sabden Valley Shales, with *Posidonia, Goniatites, Orthoceras*, etc.

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[1] This name is abundantly used in Lancashire and Yorkshire for at least two different forms of shells which have been studied by Mr. H. Bolton and myself. I have referred them to *Posidonia lævis* and *P. minor*, Brown, sp., and they form a part of the matter to be published in this year's portion of my Monograph on "The British Carboniferous Lamellibranchs," by the Palæontographical Society.

A similar sequence is seen from Ribchester to Chipping, across Longridge Fell, which is capped with Upper Pendle Grit. The third and fourth grits are seen in the River Ribble, north of Longridge; and below the escarpment the Lower Pendle Grit forms a feature. Below this are the Pendleside limestones, which rest on shales, and near Chipping is the Carboniferous Limestone.

At Ashnot, one and a half miles south of Newton, is the outcrop of a small patch of limestone in the shales, which, from its position, would appear to belong to the Pendleside limestones. This patch is very fossiliferous, and twenty-three typical species of Carboniferous Limestone forms are said to occur there. Mr. Tiddeman says of it (p. 19, Burnley Memoir): "It bears a stronger resemblance to the Great Scar Limestone than any other beds which I know in a like position."

No other district shows such a thickness of shales between the limestones as obtains in the Pendleside area; indeed, deposition of mud here was locally very excessive; on Pendle Hill, however, the Upper Pendle Grit is nothing like so thick as it is on Longridge Fell, where it is about 1200 feet. Traced north-westward, the beds between the Pendle Grit and the limestones rapidly diminish; and about two miles south-west of Slaidburn (the beds dipping at the average of 30° in three-quarters of a mile) we pass from Mountain Limestone to Pendle Grit, and two miles further north-west the Pendleside limestones have disappeared, and the grit is reduced to a comparatively thin bed, which forms a feature in Ramsclough.

Further north-west, in the Carnforth district, the grits and shales are still thinner, and no limestones exist in the shales between it and the grits; the Pendleside Grit, 1200 feet thick at Longridge, having entirely vanished, together with several hundred feet of shales with limestones, in about twenty miles.

Traces of the Pendleside limestones are seen in scattered localities, e.g.: near Cold Coniston, on Embsay Moor near Skipton, and at Studfold, near Draughton; but the intervening shales thin out rapidly to the east. The fauna is typically that of the Carboniferous Limestone, and almost entirely different from that which occurs in the Bowland Shales. A few miles north of Skipton the beds between the limestone and the grit thin out very rapidly, and in Niddale (vide p. 168) are reduced to a very few feet. A good section can be obtained in the streams on Burnsall Fell, between it and Hill Bolton. Here, unless there be an overlap of the grits or an unmapped fault, there are only about 300 feet of shales, and no limestones beyond the main mass, nor any features indicative of such. Only about one and a half miles north of Burnsall, which would be north-east of the line of the sequence given above, but on the other side of the Craven fault, a distinct limestone, but only one, is seen to occur in the shales between the grit and the limestone. Tracing this bed northwards, it forms a feature north of the village of Hebden, and it is supposed by the Officers of the Survey to split into two beds north of Grassington, which become amalgamated with the main mass of limestone still further north. Phillips gives at p. 30, "Geol. Yorks.," ii, a measured section of the beds on the west flank of Great Whernside, as follows:—

		ft.	in.
	Bearing grit	100	0
277 ft. 6 in. Upper Limestone Group.	Plate	84	0
	Sharp, hard limestone	6	0
	Parting		
	Light-coloured limestone	9	0
	Parting		
	Light-coloured limestone	36	0
	Parting		
	Light-coloured limestone	60	0
	Plate	4	6
	Dark-coloured limestone	78	0
	Limestones and some gritstones and plate ...	210	0

It will be noted that the figures given of his Upper Limestone Group total up to 277 ft. 6 in., so that the partings are so thin as to be practically neglected, and the only bed of shale of any measurable size, 4 ft. 6 in., which might have served as a base-line, is not so used, but apparently hypothetical lines are chosen for the subdivision.

Tracing the beds to Starbottom and Bishopdale, the shale beds gradually thicken to the north-west, and beds of sandstones become intercalated with them; and this series of beds, which measures 277 ft. 6 in. at Great Whernside, is increased to 510 feet at Starbottom.

If the Carboniferous succession be examined on the western side of the Pennine anticlinal, the first indication of any limestone between the main mass and the Millstone Grit is to be seen in the Outside Pastures east of Lancliffe Scar, between that locality and Malham Tarn. This patch of ground is much faulted, but a bed of dark limestone, with a low dip, is seen in the shales of the brooks, and it forms a feature in Black Hill, which is capped with Millstone Grit. It is quite possible that this bed may be the equivalent of the Pendleside limestones, but if so the shales are much diminished, especially between it and the limestone mass below.

In the side of the hill below Black Hill is a patch of ground where a small stream comes out at the junction of the limestone and the shale below it, called Clattering Sykes. This stream washes out thousands of encrinite rings and a few other fossils, as *Orthis Michelini*, *Spirifer*, *Productus*, etc., which are left on the ground. These are doubtless derived from the shale bed, which holds up the water which has sunk through the thin bed of limestone, and show the continuity of the fauna of the mass of limestone during the deposition of the shales.

Three miles north of Black Hill is Penyghent, with 500 feet of strata between the main mass of limestone and the Millstone Grit which caps it, and in the 500 feet are no less than four beds of limestone. In Ingleborough this series measures 900 feet, and on Whernside 1000 feet, and the Great Scar Limestone is only about ·600 feet thick, so that here the whole series is no thicker than the Mountain Limestone of Derbyshire.

Immediately north of the districts mentioned above is Wensleydale,

where the beds, with from five to eight thick beds of limestor
which the name Yoredale Series was given, are typically developed
they extend to about 1500 feet in thickness, but the Great Scar I
stone below this series is only estimated to be 600 feet. In the
of Yorkshire the massif of limestone itself is probably about 200
thick, but its base has nowhere been seen. This diminution in de
is not in any way due to denudation, for no evidences of unconfo
are to be observed. The Carboniferous Series as develope
Wensleydale can be fairly well traced northwards into Swal
and Teesdale, but still north of this there is a tendency to subdi
and variation, and the Great Scar Limestone becomes the Meln
Scar Series.

In the neighbourhood of Ash Fell and Roman Fell an intere
series of sandstones with plant-remains, limestones of tole
thickness, conglomerates, and shales, is developed below the
Scar Limestone, the most southern trace of the Calciferous
stone Series so much more fully developed in Northumberlan
Scotland, and which would appear to be stratigraphically belo
Carboniferous Limestone mass of Central England.

In certain districts of England the Carboniferous Limesto
immediately overlain by the Millstone Grit (Coalbrookdale and
Hill). This is generally said to be the case in Flintshire al
the beds classed as Millstone Grit really belong to that forma
which I doubt on palæontological grounds. In the Forest of Dea
intervening beds are estimated at 116 feet (Wethered). At C
about 300 feet of shales, sandstones, and limestones occur betwee
grits and the main mass of limestone, and here the limestone
is largely present. In South Wales the Carboniferous Limesto
succeeded by the Gower Series of about 1600 feet of black shale
sandstones. At Tenby they are only represented by a few feet,
beds of limestone, and contain Goniatites. Mr. H. B. Wood
("Geol. Eng. and Wales," p. 167) says they remind one o
Black Limestones of North Devon that occur at the base o
Culm-measures.

In Europe and North America the intermediate beds bet
the calcareous beds of the Carboniferous period and the
measures seem to be to a large extent wanting, and
misfortune is, that an attempt has been universally made to corr
these beds with those of a series in Great Britain which have
chosen as a type, and to identify certain well-marked beds with o
which have a purely local character. A fuller and more acc
knowledge of Carboniferous palæontology will, however, in
establish a better basis for comparison.

In the Carboniferous Series of North Wales, Mr. Morton has s
(Proc. Liverpool Geol. Soc. 1881–2) that the following
obtains:—

Cefn y Fedw Sandstone.
Upper Black Limestone.
Arenaceous Limestone.
Upper Grey Limestone.
Middle White Limestone.
Lower Brown Limestone.

The Geological Survey has considered the uppermost member of this series to be the equivalent of the Millstone Grit, because it passes into a pebbly sandstone further south. Mr. Morton has shown that at Pentre Halkin the white shale interstratified with the chert beds contains ***Chonetes Laguessiana*** and ***Productus longispinus.*** Several other typical Lower Carboniferous species are stated to be found in these so-called Millstone Grit beds, on the authority of the Survey; but I am bound to admit that ***Aviculopecten papyraceus*** and ***Posidonomya Gibsoni,*** whatever may be meant by this last name, are credited the former to one and the latter to two localities, undetermined Goniatites also occurring with the former.

Mr. Morton observes (Trans. Manch. Geol. Soc., vol. xvii, p. 81, 1883): "As the fossils found in the Cefn y Fedw sandstone are all common limestone species that occur in Denbighshire and Flintshire, it seems possible that the formation is an arenaceous continuation of the Carboniferous Limestone."

At Saith-aelwyd the chert beds are immediately above the Black Limestone. The section of the chert beds at Afongoch[1] gives—

	feet.
Banded chert	6–8
Chert full of encrinites	3
Chert and limestone—sometimes all crystalline limestone, sometimes containing blocks of chert with a heart of limestone, or vice versâ	1
Banded chert	8

It is definitely demonstrated that the chert has either replaced limestone or was deposited at the same time. It is very questionable, therefore, whether strictly any equivalents of the Millstone Grit occur in North Wales. It must be remembered also that, although sandstones of various degrees of coarseness are known in the Lower Carboniferous Series, chert beds are conspicuously absent in the Millstone Grit Series of Lancashire and Derbyshire.

I have been impressed with the occurrence of beds of stratified chert in the Upper Yoredale Series of Wensleydale, and the fact that similar beds occur in the upper portion of the Carboniferous Limestone of Derbyshire; and, although I would hesitate to say that this occurrence of beds of similar chemical characters in the upper beds of the two series is any positive evidence as to these beds being either the chronological or homotaxial equivalents of each other, I give the fact for what it is worth as indicating one other feature which the massif of Carboniferous Limestone and the Yoredale beds of North Yorkshire have in common.

I have written elsewhere (GEOLOGICAL MAGAZINE, Dec. IV, Vol. III, p. 259):—"The Carboniferous series of Northumberland and Scotland are essentially characteristic of those [beds] deposited near a shore which occasionally became land, and occasionally was depressed deep enough to allow limestones to accumulate on its floor. The land which was the source of the muds and sandstones was probably of no great elevation, and consequently river-action was not strong enough to carry the sediments far out to sea." The shore-line was by no means constant in position, but advanced south and retreated back again according to the varying rates of sedimentation and depression.

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[1] Mem. Geol. Surv., "Geol. Flint, Mold, and Ruthin," p. 48.

No real break is, therefore, to be found in tracing the variations in the Carboniferous beds of England from south to north, and the great change of character is certainly due to conditions of deposit. I think, in spite of recent utterances, that the great mass of the Lake District could never have been covered by the Carboniferous sea, but remained an island or peninsula during that period. I would insist that deposits of sands and shales are essentially the débris of land, and are always shallow-water deposits; and in the case of Carboniferous sandstones and shales, the presence of plants in too large numbers to be attributed to drifting by wave-power, is conclusive evidence that such was the case. Marine erosion practically only takes place for a short distance beyond low-water mark, and an examination of conglomerates points to the locality whence the fragments were derived. The fragments of Silurian rocks which are found in the Basement Conglomerate bed are nearly all subangular, and have therefore not been rolled much or carried far; but apart from evidence it is a necessary conclusion that encroachment of the sea must have been gradual, and therefore there must have been an advancing or retreating shore for some period of time or other after the earth-movements, which threw the older rocks at such an angle that the basement beds of the new (Carboniferous) deposit were laid down on the fractured and upturned edges of the older beds.

In the South Midlands depression and sedimentation seem to have gone on at a fairly uniform rate for a long period of time, interrupted only by conditions which have left their mark in their shaly partings, rarely exceeding more than a few inches in thickness. In the North and nearer the shore-line, sedimentation was often so far in excess of depression that the terrestrial conditions necessary for the growth of the coal flora obtained. But there came a time even in the southern area when the deposit of limestone became less constant, and instead of the massive deposit the beds are thinner and assume a more fissile character, these being succeeded by shales containing thin limestones, which in turn are covered in by thick beds of black shale, with occasionally beds of fine, hard, gannister-like sandstone, all of which are, however, peculiar to the Derbyshire and South Yorkshire area. These beds, in common with those of Wensleydale, have received the name of Yoredale Beds, but, unlike them, contain no limestones, except a few irregular, thin bands at the extreme base. If I am correct in my contention that the Yoredale Series of Wensleydale are simply the equivalents of the upper beds of the Carboniferous Limestone (and several authors have seemed to acquiesce in this view) and do not overlie it, then the term Yoredale can no longer be retained for the mass of strata which intervenes between the Millstone Grit and the Carboniferous Limestone in South Yorkshire, Derbyshire, and North Staffordshire.

It would appear that this series is practically absent in the north of Yorkshire, or only represented by a few hundred feet of shale immediately below the Millstone Grit. The officers of the Geological Survey have of late years relegated all the beds to the base of Farey's Grit, called also the Shale, Yoredale, or Pendle Grits, to the Millstone Grit Series, and they further raise the question ("The Geol. of the Carb. Limest. Yoredale Rocks and Millstone Grit of N. Derbyshire," p. 7: Mem. Geol. Surv.) as to whether the quartz gannister-like sandstones of North Staffordshire should not also be grouped with this division. They argue that the question depends on the condition under which these beds were deposited. If these conditions were marine, then the beds are to remain Yoredale; if estuarine, to be included in the Millstone Grit. In the absence of fossils they are retained provisionally as Yoredale beds. Now these quartzose rocks do contain plant-remains in certain localities—Gun Hill, Leek Waste, and Congleton Edge—and may therefore be said to be non-marine, and consequently the Yoredale sandstones of North Staffordshire fulfil the conditions laid down by the Survey for classification as Millstone Grit Series. But the matter is really not quite so simple as all this, for occasional marine bands are to be seen in the shales with bullions which separate some of the gannister-like beds containing a typical marine fauna. Indeed, there are two distinct marine faunas present in the shales, which do not intermingle,—one typical of the deposit and the beds above,—the other consisting of species common to it and the beds below, and only very local in its occurrence.

That which I call the typical fauna of the deposit, and which comes in at this horizon for the first time, is itself a very important one, and differs very markedly and in every particular from the fauna of the Carboniferous Limestone and its equivalents in Wensleydale and Scotland, in which districts no trace of the other group of organisms has been found.

This series of black shales with sandstones are exposed in the bottoms of the valleys in South-West Yorkshire, at Mossley, Saddleworth, Marsden, and further north at Todmorden, Hebden Bridge, Sabden, and Flasby, and the escarpment of Pendle Hill, in Lancashire at Longridge Fell, and are overlain by the Millstone Grits. I have alluded to the latter sections above, and will merely repeat that this series rapidly thins out to the north, until the mining section at Greenhow Hill shows only 12 feet of limestone and plate between the lowest Millstone Grit and the main mass of limestone. The late J. W. Davis ("West Yorks.," p. 76) says:—"In Upper Wharfedale and Nidderdale there are about 20 feet of shale and dark-coloured limestone between the Lower Limestone and the Kinderscout Grit. The course of the River Nidd above Lofthouse runs in the Lower Scar Limestone. This is seen covered by 4 ft. 6 in. of shale with thin clayey limestones in its upper part; then follow 6 feet of blue limestone, 14 inches of shale, and 5 feet of black, compact, laminated limestone. Above the laminated limestone the lower beds of the Millstone Grit crop out."

As far as I can see, the only stratigraphical difficulty which presents itself is the occurrence of the Pendleside limestones at such a distance from the main mass as 2500 feet. But it appears to be very local in its development, and it is certainly not to be traced to any distance except perhaps to the north-east, while the great mass of shale itself thins out very rapidly in the same direction. The Pendle Hill and Longridge sections are extremely valuable, for they both exhibit a complete sequence from Coal-measures to the Carboniferous Limestone. It must also be remembered that the whole of the Millstone Grit Series is really a very local deposit, only appearing in force in South Yorkshire, in Lancashire and Derbyshire, rapidly thinning out both to the north and south.

(*To be concluded in our next Number.*)

VI.—FOREIGN BOULDERS IN THE CHALK.

By EDWARD A. MARTIN, F.G.S.

THE recent find by Mr. Stebbing, F.G.S., of two large boulders of granite in the Middle Chalk of Betchworth (Surrey), has called to mind the various discoveries of boulders which had previously been made in the same marine formation by other observers.

I am not aware whether the discovery of the so-called Purley syenite boulder (from the Haling Pit, South Croydon) has ever been considered in connection with that remarkable boulder which was dredged up by the "Challenger" off Halifax. This, too, was of syenite, and weighed no less than 5 cwt., and was brought up from a bottom of grey mud containing many foraminifera. Whatever could be said on behalf of some of the boulders from the Chalk having been conveyed by floating seaweed, or the roots of trees, the probabilities are all in favour of this block having been transported by ice, in a sea where so many icebergs are found at certain seasons of the year. And this without the necessity of inventing a special Glacial Epoch. We may argue from the one to the other, and without any very great stretch of imagination see the work of an occasional iceberg in the occasional occurrence of a boulder of foreign material in the Chalk.

The great Purley or Haling boulder, the boulder from the Gayton Pit, Norfolk, and others, are all thoroughly rounded. From this reasonably follows that they must have suffered much before being imbedded in the iceberg, perhaps on that shore which existed around those portions, comparatively small, of modern Europe, which even then were raised high and dry above the Chalk sea. The Betchworth boulders are not nearly so rounded. Added to this, fragments of *Spondylus* and *Serpulæ* are still attached thereto. Icebergs take a long time to melt, and I think there is just as much likelihood of *Serpulæ* becoming attached to a submerged block of granite as barnacles to a ship's bottom. At the same time the presence of *Serpulæ* seems to show that there could not have been a "Glacial epoch."

Whence flowed the currents which bore the icebergs? Dr. W. F. Hume said from the south. So far as I know, the Dartmoor granite does not vary much. At any rate, I can speak for the great resemblance of the Betchworth granite boulder "B" to the granite of Hey Tor and that of Lustleigh Cleave, and thereabouts. The large crystals specially bear a great resemblance. Professor Bonney gave a tentative opinion as to their Scandinavian origin, but apparently with no great degree of positiveness. I suggest, therefore, that the conveying current may have been from the south-west. The Dartmoor Tors have undoubtedly suffered much denudation. Perhaps they extended above the level of the Cretaceous sea, and gave rise to an Alpine glacier even in the midst of an equable climate.

As to the decomposition which Mr. Stebbing's boulders have undergone, I think we may assume that the change has taken place since their interment in the Chalk. I understand Mr. Stebbing did not actually see them excavated, otherwise it would have been interesting to have known whether there were smaller fragments or any sand around them, as in the case of the Purley or Haling boulder. I saw some blocks of chalk and a somewhat similar granite, which had been used together as building materials, in the foundations of the old Blackfriars Monastery. These were excavated about 1886, near the western end of Knightrider Street, to make room for some new post-office buildings which were then being erected. The chalk was comparatively intact. The granite was in just such a condition of disintegration as was exhibited by the two Betchworth boulders.

REVIEWS.

I.—MICROSCOPIC AND SYSTEMATIC STUDY OF MADREPORARIAN TYPES OF CORALS. Philosophical Transactions of the Royal Society of London, vol. clxxxvii (1896), pp. 83–345. By Miss MARIA OGILVIE, D.Sc.[1]

THE criticism which a work like this calls for may be taken as an index of its importance. No one who has worked at the corals will deny that Miss Ogilvie has the merit of advancing our knowledge by a considerable amount of solid work; we warmly congratulate the gifted authoress upon it. But the critic's task is to criticize, and the pleasanter congratulations must be hurried over in order that we may endeavour to estimate the value of the work done. It must be understood that I set this task before myself as a reviewer in no arrogant spirit, as claiming the superiority of a judge. A criticism is no more infallible than the work criticized. A review at its best is but the calm and impartial opinion of a fellow-worker in the same field. As no two workers approach a subject from exactly the same point of view, no two having worked with the same material, or treated what material they have had in exactly the same way, everything is to be gained by free criticism of one another.

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[1] Mrs. John Gordon.

While not here primarily concerned with the work as a literary roduction, it is impossible to avoid expressing a regret at its really reat and needless length. Further, one notes a looseness in the se of certain words which is harmless unless the word itself appens to be important. The authoress's use of the word homologous" is so ambiguous, indeed, that some of her sentences, ven when their real meaning as gathered from the context is orrect, do her injustice. For instance, on p. 158, "a single branch of the ***Mussa corallum*** is the homologue of the whole massive orallum of a *Heliastræa* or *Goniastræa*"; and again, "a single tooth of a ***Mussa*** septum is the exact homologue of the complete septum of *Galaxea*."

Coming now to the scientific portion of the work, in a short review it is only possible to refer to the leading points. Von Koch, Fowler, and Bourne had already established that the coral skeleton was secreted by the ectoderm; Miss Ogilvie finds that this takes place by the actual calcification and death of successive layers of ectoderm cells, the supply of these cells being maintained by cell division. Miss Ogilvie does not seem quite to appreciate the importance of this latter statement; she merely asserts it. The death of the ectodermal cells and their utilization as hard units in the formation of epidermal structures is well known in the animal kingdom, but as to the method of replenishing these cells much has still to be learned; hence, while not doubting Miss Ogilvie's observations, zoologists will be generally disappointed that she dismisses this very important part of the observation without any figure, and in less than a single line.

The septa being secreted in folds of the ectoderm are composed of two apposed layers of skeletal matter. These septa not only rise in height, but mutually support one another in different ways: for instance, local thickenings of adjoining septa, or granules from their faces, may meet and fuse. Here is Miss Ogilvie's second solid contribution, continuing and amplifying the work of Pratz. She finds that these septa with their outgrowths are not only built up of discarded calcified cells, but that these cells are grouped into units of structure of different orders and degrees of importance. Before discussing these structural elements and her application of them, I must call attention in passing to a doubtful use of words. In describing these septa and the outgrowths from their lateral surfaces, Miss Ogilvie continually speaks of invaginations of the wall being filled up by skeletal matter. On p. 125 we find: "Is the ectoderm smooth, so is the skeletal lamella. Is the ectoderm wrinkled, pitted, grooved," etc. See also pp. 137, 138. On p. 180: "New invaginations . . . . give rise to new centres of calcification." And again, "invagination" is sometimes most confusingly used where the object referred to is the skeletal part contained in it. Is not this a begging of the question and thus misleading? Are septa and their surface-granules and synapticulæ formed by active infoldings of the body-wall which are secondarily filled up by coral substance? There seems to me some confusion of thought in the use of this terminology. It is true that when any portion of the basal body-wall resting upon a single layer of the secreted skeleton leaves that layer, it has undoubtedly been pulled off by the growth of the skeleton raising up the whole animal. In this case the skin typically proceeds to secrete another layer as soon as it has come to rest, these secondary basal layers forming "dissepiments" or "tabulæ," according to their position in the calyx. It appears as if this active withdrawal of the body from its flat skeletal floor has led Miss Ogilvie to attribute the formation of septa also to active infoldings of the wall. Is there any evidence for this? My own impression was, that the active secretion of solid matter by the aboral ectoderm was prior to the formation of septa, and thus sufficient of itself to account for the septa. The more active secretion of the ectoderm in the bases of the intermesenterial chambers would cause the passive pushing in of the aboral wall by radially arranged deposits. Wherever, in fact, for any cause, the secreting activities are increased the wall is passively pushed in by the hard matter deposited. The very disordered order of the centres of calcification revealed to us by Miss Ogilvie's sections is, it seems to me, more in keeping with this suggestion than with what appears to be Miss Ogilvie's own view of the matter. But, however clear and correct Miss Ogilvie's own views on this subject may be, she certainly leaves the reader in doubt as to whether the invaginations of the body-wall are active or passive. This is not by any means a trifling point, for morphology is a vain pursuit without physiology.

The discarded calcified cells, then, are the bricks for the building up of the various parts of the skeleton, and while they are laid fairly regularly in layers ("growth lamellæ") over one another, these layers never seem to start quite regularly except when the deposit is single, e.g. for the formation of a dissepiment. On the other hand, whenever these bricks are going to bulge up the skin, which secretes them, for the formation of a septum, they seem to start, not along continuous lines, but from single points round which they radiate. These dark points are "the centres of calcification," while the cells with their crystalline contents form radiating bundles of fibres called "fascicles." Sections of septa show fairly regular groupings of the dark centres with their fascicles. A trabecula, according to Miss Ogilvie, is formed by a continuous series—single or multiple—of such dark centres rising from the base towards the upper edge of the septum, straight up or bending towards its inner or outer edge, or sometimes even horizontally arranged: the distal ends of these trabeculæ run out into teeth or septal spines, and so on: for the many interesting details the reader must consult the original work.

Miss Ogilvie, whose merit it is to have patiently examined for these details of fine structure a long series of types, recent and fossil, is able to announce that this method of building up the skeleton is the same to-day as it was in the earliest known fossil; growth lamellæ, fascicles, and trabeculæ are fixed elements in coral skeletons, and are as much units of structure, only of a higher order, as are the ultimate calcified cells out of which they are built. The importance of this to the coral worker, inasmuch as it helps to clear the view and correspondingly heightens his confidence in attacking the morphological puzzles that beset him at every turn, is certainly great. But the new weapon which Miss Ogilvie has given us she proceeds to use herself, and, while heartily acknowledging the debt, I am constrained to say that I cannot agree with the use she makes of it. I write entirely for myself, and Miss Ogilvie may take this comfort to herself, that she has the majority with her, and sins, if it is sinning, in good company. On the other hand, she seems to me to have carried this tendency to an extreme, which it is to be hoped will inaugurate a wholesome reaction.

In 1834, Ehrenberg, recognizing the coral stock as the product of a budding process, made the method of budding the factor of prime taxonomic importance, In this he was followed by Dana in 1848, and by Milne-Edwards and Haime. Methods of budding were, however, obviously inapplicable for the classification of solitary corals; hence characters relating to the structure of the calyx had to be sought. The researches of Heider, Von Koch, Fowler, and Bourne have been supplying us with the main differences in the method of building up the coral skeleton. These anatomical studies have now been, as it were, capped by Miss Ogilvie's researches into the minute histology of the skeletal parts.

Having come to the conclusion that Milne-Edwards and Haime had "practically exhausted the subject from a macroscopic aspect fifty years ago," and further that "habits of the corallum" should not "outweigh considerations of fine structure," Miss Ogilvie started "hoping to find some fairly embracive [sic] series of different structural types if such existed in Madreporaria. The result has proved that structural types do exist and form a surer method of determining Madreporarian genera and groups than any other method known to me." As we have seen, the differences of fine structure, on which Miss Ogilvie relies for the classification of the corals, relate to the various groupings of the fascicles with their dark centres and consequently of the trabeculæ.

It is a well-known human failing to treat (perhaps not theoretically, but practically) each new set of differences, especially if they are really important, as if they alone were of any value. There has been a distinct tendency to classify corals according to the anatomy of the calyx, the older, purely macroscopic characters being put very much in the background. And now we have Miss Ogilvie practically proposing to classify corals according to the histology of their skeletons.

I am, of course, far from objecting to the utilization of skeletal structure or texture in arranging the corals. But hastily to assign to these the first place in face of our ignorance of the interdependence of the vital processes themselves, seems to me somewhat unphilosophical. It is quite possible that we shall ultimately find that the structure of the calicle wall, or even that the minute structure of the septa, will supply us with the means of discovering the evolutionary history of the stony corals. But, in the meantime, I frankly confess that I do not personally regard these sets of differences now under discussion as of the very first importance, inasmuch as, in many cases, they can be shown to be secondary, and dependent upon the life of the secreting organism. I accordingly, perhaps perversely, agree with the older observers who ranked first and foremost features most intimately associated with habit of life. It seems to me that differences in structure and texture gain their real importance only as they reveal to us differences of habit. It is thus not a question of rejection of characters, but merely of selection for first, second, and third place. I can perhaps make my meaning clearer by coming once more to close quarters with the work we are discussing. On page 329 Miss Ogilvie says: —"My own opinion is that the most intelligent way of studying corals is not to approach them by means of any fixed system of subdivisions, but by some such way as I have tried in drawing up the phylogenetic scheme below, where the worker first studies the anatomy of the soft parts and the structure (microscopic) of the skeleton in one common type [sic] of each of the living families of corals. According to my classification there are ten of these." This is very good as far as it goes, but the fundamental error in it is that it supplies a miserably insufficient basis on which to build up a natural system. A few, i.e. ten, of the more striking variations in coral structure is all that can possibly be obtained by this method. Miss Ogilvie would be the last to admit that the countless transition forms revealing the lines along which these variations have travelled, are to be left entirely to the fertile brain of the individual, or even to be gained by a cursory oversight of a few intermediate specimens gathered at random here and there. Further, Miss Ogilvie's chief types are in reality selected in the first instance at random. What can be said for such a principle of selection as the following? (p. 326): "Besides, I hold that, as the Poritidæ are reef-builders, on the grandest scale known in the Madreporaria, it is the reef-type which should be taken as the standard for the family, and not the small astræiform colonies formed by some species." And why is *Turbinaria mesenterina* chosen as specially typical of the genus: may it not be an extreme form?

But this is not peculiarly Miss Ogilvie's method. The tendency to exaggerate the morphological value of the one or two isolated types studied is almost universal. For instance, the detailed study of the development of a single mite has recently been made the basis for a lengthy discussion on the phylogeny of the whole class Arachnida.

Indispensable as is a thorough knowledge of types of calicle structure, I repeat that it is not enough to build a phylogeny upon. These types are not fixtures; they are only stages in the evolutionary processes, and the only philosophical method of dealing with them is to endeavour to find out the lines along which they have travelled. This can only be done by careful comparison of the available generic and specific variations presented by each. I venture to think that the importance of not a few structural features of the calyx would be found to melt away before such a process. By way of an example I may note that Milne-Edwards and Haime united the genus *Montipora* with *Porites* on account of the trabecular character of the septa of the former. A more extended survey of the genus *Montipora* would have shown that the variation in the structure of the cœnenchyma and of the anatomy of the calyx is very great; and that the trabeculæ which are so pronounced in a large number of Montiporan types are purely secondary, and that every stage in their development can be traced from the simpler types which ally the genus with the Madreporidae. Again, Miss Ogilvie speaks of the "importance" of certain structural features in the columella of *Turbinaria*. Her type-method has led her to assume that what she finds in *T. mesenterina* was necessarily of importance. I have taken the trouble to look at about a dozen different types of *Turbinaria*, and did not find a single other type showing Miss Ogilvie's important feature. The columella in *Turbinaria* is astonishingly variable. Again, in dealing with the same coral, Miss Ogilvie assumes that the wall structures are formed nearly contemporaneously with the septa, and thus the interseptal loculi are typically cut off round the rim from the canals of the cœnosarc. A more extended survey of Turbinarian types would have shown Miss Ogilvie that the interseptal loculi very frequently run into the surface cœnosarcal canals. Or, again, Miss Ogilvie compares a calyx of *Madrepora* and a calyx of *Turbinaria*, the calicles taken at random. Anyone who has spent any time studying and comparing these genera must be convinced that their highly specialized method of budding has profoundly modified the daughter calicles. The axial calyx in *Madrepora* and the skeleton of the single parent polyp of the Turbinarian stock before the ring of daughter polyps have begun to form the cup, are the only ones that could be relied upon for structural comparison with other coral types.

But if this doubt prevails as to the supreme taxonomic importance of the grosser features of calicle structure, what are we to say of the finer texture of the skeletal parts upon which Miss Ogilvie would found a natural classification. A mere formative tissue, following, as it must do, every form variation, however insignificant, is a shifting sand upon which no one should try to build up a phylogeny. Miss Ogilvie could only establish her case by showing that the different units of skeletal structure, fascicles, and trabeculæ had some clearly recognizable morphological significance as such and were not merely component parts, produced wherever required, more or fewer as the case might be, of no more significance than are the individual fibrils in a muscle or nerve fibres in a nerve strand. A certain ordered complexity of structure is not enough: the muscle fibril is an organized body of marvellous complexity, yet it has no morphological significance whatever in settling the homologies of the muscles themselves. How entirely Miss Ogilvie has missed this may be seen from her "homologies" already quoted, and from the difference, asserted and reasserted, between synapticulæ and pseudo-synapticulæ. If the septa are near enough for two granules to meet and fuse, it is a pseudo-synapticula; it is a true synapticula only if the space is too wide and a new "fascicle" or bundle of calcified cells has to be formed so as to unite them. A figure is given showing two septa converging towards and meeting in the centre of the calyx; where the space between these septa to be bridged is wide the junctions are called synapticulæ, but towards the centre they are called pseudo-synapticulæ, the sole difference being that more formative material was wanted to bridge the wider than the narrower interval! We need, I think, hardly wonder if classification on such lines as these results in the establishment of "mixed types."

As an example of Miss Ogilvie's method, let us take her conclusion that the cœnenchyma of the Madreporidæ is not a true cœnenchyma, but a "mural" structure homologous with the root-processes of *Rhizotrochus*. Miss Ogilvie distinctly tells us, p. 268, that but for the "*identity*, in groups apparently wide apart, of the *microscopic structure of the septa and of the wall*, as well as the similarity in the internal plan of the calyx," this "homology" would never have occurred to her (the italics in the quotation are not mine). In order to work this out she has to deny that the Madreporidæ possess a true "edge-zone" (or Rand-platte of Heider), because when the mural and septal structures grow up contemporaneously the interseptal loculi are not continued over the wall into the extrathecal canal system! Such a statement as this would have forced us to conclude that she did not quite grasp the relations between the polyp and the skeleton, if her own figures had not shown the contrary. She entirely rejects Bourne's suggestion that the absence of the remains of mesenteries outside the calyx may be due to secondary degeneration.

The whole argument seems to me singularly unfortunate. It looks likes a needless turning away from the obvious teaching of her own figure, which shows the relation of the flesh to the skeleton in *Turbinaria*. Again, it is not true that the interseptal loculi of *Turbinaria* are typically shut off from the cœnosarcal canals round the lip of the calyx; extraordinary variation occurs. Lastly, it seems to me that the teaching of the epitheca is in direct opposition to her contention. At least two of the Madreporidæ, viz. *Astræopora* and *Montipora*, can be shown to start colony-building in a small saucer-shaped epitheca. There is a larger central polyp, which is the parent polyp of the colony, and an irregular ring of smaller daughters between the central polyp and the epitheca. Nothing but the severest demonstration would persuade me that that epithecal saucer is not the epitheca of the parent polyp, and that the flesh which stretches from the edge of the parent calyx to the epitheca is not an edge-zone, no matter how complicated the skeletal framework underneath it may have become. The cœnenchyma which surrounds the parent calyx, and in which the young calices are opening, can be quite naturally accounted for by the secondary alteration of the primitive costæ, an alteration which would necessarily involve the degeneration of the extracalicular portions of the mesenteries. Further, *Madrepora* and *Turbinaria* are best explained by deducing them from such a parent polyp by the different relative growths of the parent and its ring of daughters, the primitive epithecal saucer being left behind. In *Madrepora* the parent shoots up, and somewhat undeveloped daughters spring in tiers from its sides. In *Turbinaria* the ring of daughters grows up and forms a cup. The detailed evidence for this line of argument to be deduced from *Montipora* will be the subject of a paper which has already been some months in preparation. None of Miss Ogilvie's arguments on this subject seem to me to have any weight as against this much simpler and more natural reading of the facts.

The value of the rest of Miss Ogilvie's system must be left to the judgment of those who have worked over the different points. There can be no doubt that long concentration upon, and wide survey of, coral form-variations have given her an insight which her, to my mind, mistaken method cannot wholly vitiate. Her circular arrangements of the families and genera is an excellent device, though one is staggered at the boldness with which she has filled in the details. We may, however, accept these as her suggested provisional arrangement, which further and profounder study of coral variations, with the special object of tracing the lines along which these variations have travelled, will gradually emend, until our common goal has been reached, viz. a natural system of the Madreporaria.

In the foregoing pages, I have freely criticized Miss Ogilvie's conclusions from my own point of view. But whatever difference of opinion there may be between us as to what conclusions may, and what may not, be justly drawn from the new facts with which she has enriched us, there can be no difference of opinion as to the facts themselves. I am convinced that these will prove invaluable to all students of coral morphology. HENRY M. BERNARD.

STREATHAM, S.W.

II—ON THE GASES ENCLOSED IN CRYSTALLINE ROCKS AND MINERALS. By W. A. TILDEN, D.Sc., F.R.S. Proc. Royal Soc., vol. lx (1897), p. 453.

AFTER referring to the fact that many crystallized minerals contain gas enclosed in cavities in which drops of liquid are also frequently visible, the author alludes to his researches on Peterhead granite, which show that when heated in a vacuum, it gives off several times its volume of gas, consisting, to the extent of three-fourths of its bulk, of hydrogen. Since these observations were made Mr. A. W. Wright has obtained hydrogen from a certain "trap" rock in America, and Professor Dewar and

Mr. Ansdell have found hydrogen in both gneiss and felspar. Professor Tilden has now examined granophyre from Skye, gabbro from the Lizard, pyroxene gneiss from Ceylon, gneiss from Seringapatam, and basalt from Antrim, and he finds all to yield permanent gas when the rocks are heated in a vacuum. This gas varies in amount from a volume about equal to that of the rock to about eighteen times that volume. It usually consists of hydrogen in much larger proportion than that found by the observers just quoted, together with carbon dioxide and smaller quantities of carbon monoxide and hydrocarbons.

Referring to the presence of marsh gas ($C\,H_4$) in the several rocks examined, Professor Tilden observes that the occurrence of this gas, and the production of large quantities of hydrocarbonous gases, as well as liquid petroleum, in many parts of the earth's surface, tend to support the view, which is apparently gaining ground, that in the interior of the earth's crust there are large masses, not only of metal, but of compounds of metals, such as iron and manganese, with carbon. Assuming the existence of such material, it is easy to conceive how, by the action of water at an elevated temperature, it may give rise to metallic oxides and mixtures of hydrogen with paraffinoid and other hydrocarbons. This view was put forward some years ago by Mendelejeff, and has been supported in the article, previously noted, by Moissan.

III.—Chemical Geology: Étude des Carbures Métalliques.

By M. Henri Moissan. Proc. Royal Soc., vol. lx (1896), p. 156.

THE author gives a summary of his remarkable researches on the formation of metallic carbides by the aid of the electric furnace, and on the compounds produced by the action of water on these bodies.

The carbides of calcium, strontium, barium, and lithium, when acted upon by water at ordinary temperatures, give rise to pure acetylene. Carbide of aluminium gives rise to pure marsh gas. Carbides of cerium, lanthanum, yttrium, and thorium yield a mixture of acetylene and marsh gas. Carbide of manganese yields a mixture of marsh gas and hydrogen. Carbide of uranium gives rise to marsh gas, hydrogen, ethylene, and also to solid and liquid hydrocarbons.

The author calls attention to the bearing of the facts on certain geological problems. Exhalations of marsh gas may, in certain cases, be due to the action of water on carbide of aluminium. Petroleum and allied compounds, which are in some instances undoubtedly due to the decomposition of organic matter, may in others be formed by the action of water on certain metallic carbides at a high temperature, as suggested by Mendelejeff.

It is probable that in the early periods of the earth's history nearly the whole of the carbon was combined with the metals. The intervention of water would give rise to hydrocarbons, and these by oxidation would produce carbonic acid. The assumption of the existence of metallic carbides in the interio earth will explain the formation of hydrocarbons a phenomena observed in connection with volcanic eruptions.

J. J

IV. — Geology of Africa.

THE Geology of Africa in relation to its mineral weal title of a paper read before the Federated Insti Mining Engineers in 1896, by Mr. Walcot Gibson, F.G paper, accompanied by a neat little map printed in colours been published. The map shows very clearly the general of the great continent, or rather of the considerable portio which we have information that can be represented on a g map. There is yet a large area extending from British I land northwards through the Congo State and to the sou Libyan Desert, which for the present remains blank, but w long will be made more accessible by the railway in construction from Mombasa to Uganda. Roughly speaki ever, we still know nothing (or next to nothing) of the g a tract almost equal in size to the whole of Europe. Geological Record is well represented in Africa, is evident full Table of sedimentary and eruptive rocks; but as tl remarks, "by far the larger portion of the continent as y is composed of metamorphic crystalline rocks." These ro indications of containing many valuable and precious they are not so barren as would appear at first sight, knowledge of them is at present very scanty. The c schists appear to be richest in the territory of the Charte pany. Newer than this metamorphic series is the famou formation of South Africa; its precise age, however, has determined. Nor is it possible as yet to state definitely sequence on the Rand, for, as the author has himself sho is much overthrusting of the strata.

Attention is directed to the various beds of coal, to the p of asphalt-deposits being found in East Central Africa, and other matters of practical interest. The general structu continent and the leading facts relating to its geology ar pointed out, and the author gives a useful list of the leadi on African geology. He rightly urges that "sooner a mineral survey of South Africa will have to be serious taken, in order to arrive at some approximation as to t and distribution of the mineral-bearing districts. South A this country would have everything to gain by a Go Geological Survey, as such a survey, being made indepe any personal interest, would tend to reassure the investi and convince it that the mineral wealth of South Afric great."

REPORTS AND PROCEEDINGS.

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GEOLOGICAL SOCIETY OF LONDON.

I.—ANNUAL GENERAL MEETING.—February 19, 1897.

Dr. Henry Hicks, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1896. In the former the Council referred to the uninterrupted financial prosperity of the Society, and announced that, for the first time in a period of five years, there had been an increase in the number of Fellows.

During 1896 the number of Fellows elected was 62: of these 48 qualified before the end of the year, making, with 11 previously elected Fellows, a total accession of 59 in the course of the twelvemonth. During the same lapse of time, the losses by death, resignation, and removal amounted to 47, the increase in the number of Fellows being 12. The total number of Fellows, Foreign Members, and Foreign Correspondents stood at 1329 on December 31, 1896, as compared with 1318 at the end of 1895.

The balance-sheet for the year 1896 showed receipts to the amount of £3728 0*s.* 5*d.* (including a balance of £851 15*s.* 5*d.* brought forward from the preceding year), and an expenditure of £2959 17*s.* 5*d.* There was an actual excess of expenditure over current receipts of £83 12*s.* 5*d.*, but the excess was entirely due to expenditure of a non-recurring character, and there still remained at the end of 1896 a balance of £768 3*s.* available for the extraordinary expenditure contemplated in the estimates submitted to the Fellows.

The completion of vol. lii of the Society's Quarterly Journal was announced, as also the publication of No. 3 of the Record of Geological Literature added to the Society's Library, and of Part I of the General Index to the first fifty volumes of the Quarterly Journal. It is hoped to issue to the Fellows the second part of the Index within the next six months.

The institution of a Fund, to be entitled the Geological Relief Fund, of which the Council will be trustees, was announced. It is proposed that the interest accruing from this fund should, from time to time, be applied by the Council in aid of deserving Fellows. The response to the appeal for subscriptions has not, so far, been quite as general as the Council had ventured to hope.

The question as to the desirability of transferring the Society's Collections to the Trustees of the British Museum had been brought up for consideration at a special general meeting on May 20 last, and, after a prolonged discussion, the previous question had been carried by 35 ayes to 12 noes.

In conclusion the awards of the various Medals and Proceeds of Donation Funds in the gift of the Society were announced.

The Report of the Library and Museum Committee enumerated the large additions made during the past year to the Society's Library, the most important of which was the presentation by ady Prestwich of 260 bound volumes of tracts, in fulfilment 'the wishes of the late Sir Joseph Prestwich.

In presenting the Wollaston Medal to W. H. Hudleston, Esq., .A., F.R.S., F.L.S., the President addressed him as follows:—

r. Hudleston,—

It is extremely gratifying to me that it has fallen to my lot to present to you, on half of the Council of the Geological Society, the highest award which it is in ɜir power to bestow on distinguished geologists. You have laboured long and ;iduously in the cause of science, and have enriched geological knowledge in its ɛmical, mineralogical, palæontological, and stratigraphical departments. The ɜt paper which you communicated to this Society appears to be that "On the ıemical Analysis of the Cambrian Rocks," which you were good enough to dertake at my request in the year 1875. You had previously communicated papers the Geologists' Association—one on the Yorkshire Oolites, and another, in conıction with Mr. Hilton Price, on the Thames Valley Deposits. Another valuable ɛmical paper should be referred to, namely, "On the Chemical Composition of the ›cks of the Lizard," which appeared as an Appendix to a paper by Professor Bonney 1877; and in that year also you, in conjunction with Professor Blake, contributed highly important paper to this Society on the Corallian Rocks of England. The ldresses delivered by you as President of the Geologists' Association, of the Devonire Association for the Advancement of Science, Literature, and Art, and of this ciety, show much critical power and demonstrate your ability to convey a great ıount of valuable information in a limited space. You are further to be conatulated upon having recently completed the important memoir published by the ılæontographical Society—"A Monograph on the Inferior Oolite Gasteropoda"— ıich contains no less than 514 pages and 44 quarto plates. The great value of ur work amongst the Jurassic rocks is so generally admitted that I need not refer the other papers contributed by you to various Societies.

In conclusion, I can only say that it gives me very much pleasure to hand to you is Medal, which is presented by the Council as a token of their recognition of the ıinent services rendered by you to Geological Science.

Mr. Hudleston, in reply, said:—Mr. President,—

On this occasion my warmest thanks are due to the Council, on whom the duty of ;arding the Wollaston Medal has this year devolved, for their generous interpretation my past geological career. To have received a distinction such as the foremost ologists of any country might be proud to accept, and to be enrolled in that mous band of recipients which is headed by the Father of English Geology, is leed to me an unexpected honour and gratification. If anything were needed to hance the pleasure of the moment, it is to be found in the circumstance that receive the Medal from the hands of an old friend and contemporary, whose entific career possesses so many points of resemblance with my own. For, if I ve done some work in Mesozoic geology, you, sir, are well known, both in Europe d in America, for your researches among the older Palæozoic rocks.

This particular award serves to show that the researches concerning the mineral ucture of the earth are not necessarily limited to professional enterprise, but that th the Council and the Society are ready to recognize the utility of independent ›rk, whether special or of a more general character. Our science has its ramifitions in so many others, that, whether we consider Geology in its tectonic, its trographical, or its palæontological aspect, it is incumbent upon those who cultivate to endeavour to acquire, to some extent, a knowledge of cognate subjects. Not at I would venture to lay claim to the accomplishment of much original work in y of the above departments; although I may have contributed something towards knowledge of the stratigraphy and palæontology of the Jurassic rocks of England, ıd more especially of my native county.

During the last quarter of a century the Geological Society and the Geologists' sociation have, each of them, afforded me a congenial scientific home. If in that terval it has been my good fortune to have furthered the cause which we all have heart, such service has been more than repaid by the benefits derived from mutual tercourse. Nor do I forget the advantages afforded by my relations with the ılæontographical Society, whose resources have been useful to more than one 'ollaston medallist.

In offering my thanks once more to the Council and also to the Fellows here present for the cordiality with which the Award has been received, I may truly say that this Medal will always serve as an agreeable memento of my connection with the Geological Society. So long as I live, it will give me pleasure to take an interest in geological questions, and if I cannot promise to participate very actively in the work of the future, I may at least say, as regards my past work, that this recognition of its merits is most ample, and leaves nothing on my part to be desired.

The President then handed the balance of the proceeds of the Wollaston Donation Fund to F. A. Bather, Esq., M.A., addressing him as follows:—Mr. Bather,—

The Council of the Geological Society have voted you the Balance of the Wollaston Fund as an expression of their appreciation of the excellent work in Palæontology which you are carrying on, and with a view to assist you in the original investigations on the Crinoidea upon which you have expended both much labour and capital.

From the time you left the University of Oxford and entered the Geological Department of the British Museum in 1887, you have specially studied this group of fossil organisms; and in a series of some twenty-seven papers you have not only described many interesting Palæozoic and Mesozoic genera, but have proposed a method of classification, based upon the arrangement of the plates, which will be of the greatest assistance to all future workers.

The paper which you published in 1893 under the auspices of the Royal Swedish Academy, Part I, of the Crinoidea of Gothland (4to, 10 plates, pp. 200), is a work which needs only to be seen and studied to be appreciated, and has been most highly spoken of by eminent palæontologists at home and abroad. I trust this recognition by the Council of what you have already done may encourage you to still greater efforts, so that it cannot for long be said that our English Crinoidea still need a monographer.

Mr. Bather replied in the following terms:—Mr. President,—

After serving the British Museum for two years, I decided to use the knowledge thus gained, and the opportunities there offered, for an exhaustive study of the British Fossil Crinoids, a task to which I was further urged by our much-mourned Fellow, Herbert Carpenter. I estimated that the work would take fifteen years. Half that time has now passed and I have dealt with only a few genera from a single formation. The preliminary studies and other duties, to a few of which you, sir, so kindly alluded, have contracted the time at my disposal within bounds that I long to enlarge. It is the more encouraging that my fellow-workers should honour thus highly the little that I have done, for I am not ashamed to say that the thought of these awards has been, and will be,

"a spur to prick the sides of my intent."

The student of science, however, should not think overmuch of contemporary applause. If a palæontologist, he must wrestle with his fossils, nor let them go until they have yielded all their secrets. Laborious investigation, precise description, accurate and detailed drawings: these are indispensable if he is to receive aught but abuse from a posterity even more critical than ourselves. In the continuance of work that strives, however ineffectually, to have this character, the present award will be a material and a welcome aid.

In presenting the Murchison Medal to Horace B. Woodward, Esq., F.R.S., the President addressed him as follows:—Mr. Woodward,—

The Council have this year adjudged you the Murchison Medal, with the sum of ten guineas, and it is peculiarly appropriate that the award should be made to one who has for so many years zealously worked on the Geological Survey which Sir Roderick Murchison, the founder of the medal, so long and ably directed. It may not be generally known that, like your esteemed father, the late Dr. S. P. Woodward, F.G.S. (who was our Sub-curator in 1839), you also commenced your geological career (in November, 1863) as an assistant in the Museum of the Geological Society, at Somerset House. During the past 30 years of your labours as a field-geologist, on the Geological Survey of England and Wales, your experiences have been most varied. From Newton Abbot and other parts of Devon, over East Somerset, the

Bristol Coalfield, and the Mendips, to the geology of Fakenham and the country around Norwich (where your grandfather, Samuel Woodward, the "Norfolk Geologist," laboured so earnestly 70 years ago), to Essex and the neighbouring drift-covered counties; from the Jurassic areas of Britain south of the Humber to the far-distant Jurassic areas of Sutherland and Skye—all these and more have, in turn, claimed your careful attention. Besides your very numerous Survey memoirs, maps, and sections, all prepared with much skill, you have given us a most helpful work, "The Geology of England and Wales." When President of the Norwich Geological Society, the Norfolk Naturalists' Society, and the Geologists' Association, you gave important addresses, and you have contributed numerous separate geological papers, read here and elsewhere. In addition, I must especially refer to the ever-ready help which you afford, in your office at Jermyn Street (as resident geologist), to all those who call upon you for information, help which has rightly earned for you a large circle of grateful friends.

Mr. Woodward, in reply, said:—Mr. President,—

In thanking you, sir, and the Council of this Society, for the high honour which you have now conferred upon me, I cannot help feeling that you have regarded with great generosity whatever I have been able to accomplish. I would pass by the official or professional work. That has always been a pleasure: it has also been a duty. And I would rather believe that you have taken more into consideration the extra-official or amateur work which has been the labour of leisure hours. This much I would like to say, in reference to the second edition of my "Geology of England and Wales," that the impulse which led to its production was the ambition to render some service; and to do this in the way I desired was to act somewhat independently, for I received no encouragement from publishers. That their predictions were fully justified adds considerably to the gratification with which, sir, I now receive this mark of distinction and approval from your hands.

The President then handed the balance of the proceeds of the Murchison Geological Fund to S. S. Buckman, Esq., addressing him as follows:—Mr. Buckman,—

Following in the steps of your father, Professor James Buckman, you have devoted many years to the elucidation of the Palæontology and Geology of the Lower Oolitic rocks of Dorset and neighbouring counties. In palæontology, you have dealt with the Pelecypods, the Brachiopods, and the Ammonites of the Inferior Oolite and Bajocian, the last group especially in the monograph now being published by the Palæontographical Society. Seeing that accurate work in palæontology could not be accomplished without equally detailed stratigraphy, you have investigated, with a minuteness before unattempted for Jurassic rocks, the unravelling of their geological history, and the Society has thus received from your hands an important series of papers, amongst which I may mention those on the Cotteswold, Midford, and Yeovil Sands (1889); on the so-called Upper-Lias Clay of Down Cliffs (1890); on the Bajocian of the Sherborne District: its Relation to Subjacent and Superjacent Strata (1893); and on the Bajocian of the Mid-Cotteswolds (1895). To show their appreciation of the important work which you have already accomplished, and in the hope that you may continue to work on the lines which have yielded results so excellent, the Council have felt much pleasure in awarding you the Murchison Fund.

Mr. Buckman replied as follows:—Mr. President,—

I scarcely know how to thank you for the honour which you have done me in the presentation of this award, and for the far too favourable manner in which you have spoken of such scientific work as I have been able to accomplish. You have very kindly alluded to my stratigraphical work, and have noticed its minuteness. As regards this part of my labours I have a clear conscience: it was undertaken for the purpose of understanding the genealogy of Ammonites, and its minuteness is an absolute necessity thereto. But when I think of the palæontological work to which you have referred, I feel considerable cause for dissatisfaction. Now that some nine yearly portions have appeared in the volumes of the Palæontographical Society, I ought to be approaching the end of my labours, but I find that I am actually farther from that desirable attainment than when I began, while I have far less opportunity for continuous study. And when I look back at the earlier portion of this work, I am quite dissatisfied with the survey. I must own to serious mistakes, particularly that I had not sufficiently the courage of my own opinions, and that I gave heed to the outcry about new genera and species. That was a sad mistake, but I have amended it in the later parts of my work. In this direction I have, however, far more to perform. How much—or little—praise I may obtain thereby I know not, but the fact that you have kindly given me this award as a recognition of my work encourages me to confidently pursue my way. It is for such encouragement that I most appreciate this award; and I thank you sincerely for it.

In presenting the Lyell Medal to Dr. George Jennings Hinde, F.R.S., the President addressed him in the following terms:—Dr. Hinde,—

The Council of the Geological Society have awarded to you the Lyell Medal, with the sum of twenty-five pounds, in recognition of your valuable researches in palæontology and geology, but more especially in reference to your discoveries of Fossil Sponges and other minute bodies preserved in cherts, in various formations, and the painstaking manner in which they have been elucidated by you. The experience you gained when working as a student under Professor H. A. Nicholson, in the University of Toronto, and later, under Professor K. A. von Zittel, in the University of Munich (where you obtained your degree of Ph.D., for a dissertation on the Fossil Sponge-Spicules from the Chalk of Norfolk), was an excellent beginning for your subsequent more ripened work. I need only refer to your memoirs on Conodonts from the Cambro-Silurian and Devonian rocks of North America, Scotland, and the West of England, and to your various papers, to show the great value of the original work which you have done. In your "Catalogue of the Fossil Sponges in the British Museum," and in your memoir on "British Fossil Sponges," in the Palæontographical Society, you have given us works of considerable importance. You have also published many other valuable papers which have added much to our knowledge, and all recognize that you have placed yourself in the foremost rank amongst those who have devoted themselves to the study of minute fossil organisms. The medal could not be more worthily bestowed than upon one who has always so earnestly laboured for the advancement of truth, and I have very great pleasure in handing it to you.

Dr. Hinde, in reply, said:—Mr. President,—

It gives me sincere gratification to receive at your hands the Lyell Medal, remembering that it is intended, in the words of its liberal-minded founder, as a mark of honorary distinction and as an expression that the recipient "has deserved well of the science." That so competent a tribunal as the Council of the Geological Society regards my palæontological work as meriting this recognition, is to me a source of lively satisfaction.

I can only regret that so much of the work which it is my aim to accomplish still remains to be done: the encouragement which you have given me to persevere will not, I hope, be without result, but whilst the field of investigation is ever widening and the materials are constantly accumulating, the capacity to keep level with the work becomes, with the lapse of time, a diminishing quantity. I wish here gratefully to acknowledge the large measure of help which has been freely given to me in the course of my work by my brother geologists and on the part of the Society, and more particularly my indebtedness to my friend and indefatigable colleague, Mr. Howard Fox, in working out our joint paper on the Radiolarian Rocks of Devon. For the kindly, sympathetic, and very generous terms in which you, sir, have referred to what I have done, I desire to express my warmest thanks.

The President then handed a moiety of the balance of the proceeds of the Lyell Geological Fund to W. J. Lewis Abbott, Esq., addressing him as follows:—Mr. Abbott,—

Some twenty years ago you read an important paper on the Formation of Agates before the Geologists' Association, and since then you have contributed much additional valuable information in regard to their origin. For many years you have also been a careful and energetic collector of fossil remains, and of the implements worked by early man; and the remarkable collection shown by you at the recent conversazione in the rooms of the Society testifies to your keen and accurate discrimination. Your researches, as shown in your paper on the Ossiferous Fissures in the Valley of the Shode near Ightham, published in the Quarterly Journal of the Society in 1894, and in other papers published in the Proceedings of the Geologists' Association, the Journal of the Anthropological Institute, and Natural Science, have greatly added to the faunas, and therefore to our knowledge of the history, of the Pleistocene and early Post-Pleistocene periods.

The Council in making this award desire not only to express to you their appreciation of the work which you have already done, but hope that it may be an incentive to further researches. It gives me much pleasure to place this award in your hands.

Mr. Abbott replied as follows:—Mr. President,—

I am deeply grateful to you, sir, and the Council of the Geological Society collectively, for the great honour conferred upon me in thus appreciating the results of my labours; and to you, sir, personally for the very kind, appreciative words with which you have supplemented it. There is, doubtless, a great reward in store for all those who in any way contribute to the stock of human knowledge—a reward which comes with the discovery of anything new. But, after all, there is something which is perhaps even greater to frailly constituted humanity than that: it is to receive such tangible proofs as this that others admit the value of one's labours. It comes as a potent antidote for weeks and months of almost barren research, a grateful compensation for midnight oil expended and pecuniary losses sustained, and a wholesome incentive to renewed energy in the future. I am all the more proud of the honour conferred upon me, in that it is associated with the name of the great ambassador of "the causes now in operation": for assuredly, if there be one branch of geology more than another calculated to make one realize the applicability of these, it is that in which I have been chiefly engaged, where we stand one foot on to-day and the other on yesterday, and note, with equal distinctness and certainty in each, the effects not only of sea and storm, but of the very zephyrs. But while my labours are thus rewarded, it must ever be remembered how much the value of my Pleistocene work has been enhanced by the co-operation of my esteemed colleague Mr. E. T. Newton, and I gladly welcome this opportunity of publicly expressing my deepest obligations and warmest thanks to him for his great and kindly assistance during the last sixteen or eighteen years. In conclusion, I can only express the hope that the remaining years of my life, stimulated anew by this award, will be spent in the cause which I have so much at heart, and that the result of my labours may continue not only to give me pleasure, but prove interesting and profitable to others.

The President then handed the other moiety of the balance of the proceeds of the Lyell Geological Fund to Joseph Lomas, Esq., addressing him as follows:—Mr. Lomas,—

The Council of this Society have this year awarded to you a moiety of the proceeds of the Lyell Fund in testimony of the value of your work, especially in regard to the glacial geology of the neighbourhood of Liverpool, and of areas in North Wales, upon which you have written no less than ten papers between the years 1886 and 1896. To enable you to check the accuracy of your conclusions you have also made a study of glaciation in Switzerland and the Faeröe. As showing that you have not neglected other branches of geology, I may mention also your paper on the Basaltic Dykes of Mull in 1887, and on Fossil Plants from the Carboniferous in 1895. Your recent election as President of the Liverpool Geological Society testifies to the esteem in which you are held by your fellow-workers in that city, where as a special Lecturer on Geology at University College you are responsible for most important geological teaching. It is now my privilege to be the means of handing you this award, with the hope that it may aid you in your further researches.

Mr. Lomas replied in the following terms:—Mr. President,—

You have expressed, in much too kind words, your appreciation of my work in Glacial Geology. Recognizing that the first duty of a student is to collect accurate data, I have done my best to observe and record the phenomena in my own district. If these observations have contributed, even in a small degree, towards the elucidation of a very difficult problem, I am amply rewarded.

We, of the Liverpool Geological Society, are proud to think that four of our Presidents have been honoured by marks of distinction bestowed on them by the mother Society. The encouragement which these awards have afforded cannot be overestimated. When I look down a list of those who have received this award in former years, I cannot but think that the stimulus given has greatly influenced their subsequent careers. I trust that may be so in my own case, and I shall always endeavour to prove that your kindness has not been misplaced.

In presenting the Bigsby Medal to Clement Reid, Esq., F.L.S., the President addressed him as follows:—Mr. Reid,—

The Council of the Geological Society have awarded to you the Bigsby Medal in recognition of the excellent work which you have already accomplished, and in ful confidence that it will encourage you to continue those researches with unabated vigour. Since 1874, when you joined the Geological Survey, you have been engaged in mapping many areas and various formations, but you have more especially directed your attention to Tertiary and Pleistocene geology, and your memoir, "On the Geology of the Country around Cromer," has become a classical work of reference The painstaking manner in which you have searched for evidences of plant-remains from the Pleistocene deposits merits the thanks of all, for the results have been truly remarkable and have enabled us to realize far more clearly than was previously possible the prevailing climatic conditions when they were accumulated. Besides the Survey memoirs which you have written, you have found time to contribute several important communications to this Society and valuable special notes to the papers of other authors. I feel much pleasure in being privileged to hand to you on behalf of the Council, this medal; and I may be allowed to express the hope that you will continue with the same energy that has hitherto characterized you to add to our knowledge of those special branches of the science which you have already cultivated with so much success.

Mr. Reid, in reply, said:—Mr. President,—

The bestowal of this award, for which I tender my warmest thanks to the Council makes me feel that perhaps, after all, the results of my work may not be so valueless as I have sometimes feared. No doubt, compared with the magnitude of th problems which I have had before me, the results are very small; and, when viewed as a whole, must seem disconnected. I may say, however, that the published observations have more in common than would appear at first sight. They ar the outcome of a continued attack, from different sides, of some of those problems on the correct solution of which geological progress so largely depends. I allud to the question of the alternations of climate which have taken place in bygon times; the relation of these alternations to the migration, extinction, and variation of species; and to past changes in physical geography; and lastly, to the question of the rapidity with which such changes can succeed one another. In short, my somewhat ambitious task has been that of seeking a base-line for the measuremen of geological time.

Towards the attainment of this end I have made but small progress; yet, whil following unaccustomed paths noteworthy facts are constantly discovered, and many a line of research, almost a failure from the point of view of the original inquiry has yet repaid the time and labour bestowed upon it. It is only, I am afraid, on such minor questions that I have, as yet, been able to throw any light. My problem still lies before me.

The President then proceeded to read his Anniversary Address in which he first gave obituary notices of several Fellows and Foreign Members deceased since the last annual meeting, including Auguste Daubrée (elected F. M. in 1867), H. E. Beyrich (elected F. M. in 1876), J. D. Whitney (elected F. M. in 1887), Baron C von Ettingshausen (elected F. C in 1884), Sir J. Prestwich (elected a Fellow in 1833, President in 1870–1872), A. H. Green (elected in 1862), Capt. Marshall Hall (elected in 1866), W. Sharp (elected in 1840), H. J. Slack (elected in 1849), R. N. Worth (elected in 1875), and D. Robertson (elected in 1877).

He then dealt with the recent evidence bearing on the Geological and Biological History of early Cambrian and Pre-Cambrian Times, pointing out that very different views are now held in regard to the origin of many of the Pre-Cambrian rocks from those which prevailed from twenty to thirty years ago. Then all the crystalline schists and gneisses, and many also of the granitic rocks, were looked upon as metamorphosed sediments. Gradually, and mainly from the careful microscopical work which has been carried on by so many eminent petrologists in this and other countries, we have been led to recognize that a very large proportion of the crystalline rocks previously supposed to have been sediments are igneous rocks which have been crushed, cleaved, and have suffered other changes from chemical and mechanical influences. It has been shown also that very large and unexpected proportions of the Pre-Cambrian rocks were built up from materials derived from volcanic outbursts, and that this was particularly the case in the British areas. As a consequence, few of the sediments are such as could have been deposited in marine areas favourable to organic life, or are such as would be likely to retain very definite evidence of its existence. Still, the very earliest of the Cambrian rocks, or those sediments which were deposited in a fairly tranquil sea, following the great physical changes which took place at the close of the Pre-Cambrian era, contain ample evidence that the sea which was gradually encroaching on the Pre-Cambrian land on both sides of the Atlantic teemed with life, in which probably all the orders of the Invertebrata were represented.

These discoveries had undoubtedly added most important evidence in support of the theory of the gradual evolution of organic life, and led one to speak very hopefully of finding yet earlier traces of the life-history of our globe. The readiness with which suitable forms tenanted all the areas as they were covered by the sea showed that there was abundance of life near at hand in the adjoining submerged areas, and that the changes then taking place were only such as had been going on more or less continuously on the surface of the globe from the moment when the waters began to collect or, at any rate, became suitable for the existence of life. The earliest records may have been completely blotted out by the repeated changes which had previously taken place, or may be entirely buried beneath and hidden from our view in the great oceanic areas. Still, the results obtained within comparatively recent years led one to hope that there is yet room to discover much in those areas which hitherto have been but imperfectly examined or not at all explored.

The President concluded that as geologists we feel quite certain that from the earliest Cambrian to the present time we are dealing only with a comparatively recent period in the world's history; and, as biologists, that we are convinced that innumerable successions of organic beings must have lived and passed away in the Pre-Cambrian era before such an advance could have been attained, as is manifest in those forms which tenanted the earliest Cambrian seas. Recent researches had enabled geologists and palæontologists to take up a far more satisfactory position in regard to the theory of evolution than when Darwin felt constrained to pen the following words, when referring to the imperfection of the geological record ("Origin of Species," p. 310):—"The several difficulties here discussed, namely, our not finding in the successive formations infinitely numerous transitional links between the many species which now exist or have existed; the sudden manner in which whole groups of species appear in our European formations; the almost entire absence, as at present known, of fossiliferous formations beneath the Silurian strata, are all undoubtedly of the gravest nature. We see this in the plainest manner by the fact that all the most eminent palæontologists, namely, Cuvier, Owen, Agassiz, Barrande, Falconer, E. Forbes, etc., and all our greatest geologists, as Lyell, Murchison, Sedgwick, etc., have unanimously, often vehemently, maintained the immutability of species."

The ballot for the Council and officers was taken, and the following were declared duly elected for the ensuing year:—*Council*: H. Bauerman, Esq.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; Prof. W. Boyd Dawkins, M.A., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Henry Hicks, M.D., F.R.S.; Rev. Edwin Hill, M.A.; Prof. E. Hull, M.A., LL.D., F.R.S.; Prof. J. W. Judd, C.B., LL.D., F.R.S.; R. Lydekker, Esq., B.A., F.R.S.; Lieut.-General C. A. McMahon; J. E. Marr, Esq., M.A., F.R.S.; Prof. H. A. Miers, M.A., F.R.S.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; A. Strahan, Esq., M.A.; J. J. H. Teall, Esq., M.A., F.R.S.; W. W. Watts, Esq., M.A.; W. Whitaker, Esq., B.A., F.R.S.; Rev. H. H. Winwood, M.A.; H. Woodward, LL.D., F.R.S.

Officers:—*President*: Henry Hicks, M.D., F.R.S. *Vice-Presidents*: Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; Lieut.-General C. A. McMahon; J. J. H. Teall, Esq., M.A., F.R.S.; H. Woodward, LL.D., F.R.S. *Secretaries*: J. E. Marr, Esq., M.A., F.R.S.; R. S. Herries, Esq., M.A. *Foreign Secretary*: Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S. *Treasurer*: W. T. Blanford, LL.D., F.R.S.

II.—March 10, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "Volcanic Activity in Central America in relation to British Earthquakes." By A. Gosling, Esq., H.M. Minister and Consul-General in Central America. Communicated (through H.M. Foreign Office) by the President.

The author of the communication points out that the volcano of Izalco, in the Republic of Salvador, which has been in active eruption for over one hundred years, suddenly ceased to be so within a fortnight of the period at which the communication was sent (December 20, 1896), and he notes the occurrence of seven shocks of earthquake in England on December 17, 1896. He quotes remarks concerning the volcano, which were contributed by him to the "North American Review" in January, 1896.

2. "The Red Rocks near Bonmahon on the Coast of Co. Waterford." By F. R. C. Reed, Esq., M.A., F.G.S.

The rocks which are considered in this paper have been regarded by some authorities as deposits interstratified with the Lower Palæozoic rocks of the district, while others have maintained that they are of Old Red Sandstone age. It is the object of the author to show the correctness of the latter supposition, and he brings forward evidence to prove that the red rocks rest unconformably upon the Lower Palæozoic rocks, or are faulted against them, and that the breccias of the red rocks contain fragments of the Lower Palæozoic rocks, and also of intrusive rocks which break through the latter. The red rocks also resemble deposits which are known to be of Old Red Sandstone age.

The Old Red Sandstone rocks of the district form an irregular and incomplete elliptical ring around a denuded plateau of older rocks. The incompleteness is due to the concealment of the southern part of the ring beneath the sea; but if the southern part of this ring be as irregular as the northern portion, faulted patches of the Old Red Sandstone rocks may well come in among the older rocks of the cliffs in the positions where the beds which are discussed in this paper occur.

3. "On the Depth of the Source of Lava." By J. Logan Lobley, Esq., F.G.S.

The author contends that lava cannot have been brought to the surface from a depth of 30 miles, as fissures which would serve as conduits could not exist at that depth, and, moreover, the lava would be consolidated before it reached the surface, owing to contact with cool rock for a considerable period. He argues that the pressure of the overlying rocks would cause the rocks even at a depth of 10 miles to be practically plastic, as shown by M. Tresca's experiments, and that no continuous fissure could occur in such rocks. Estimates of the volumes of ascending lava-columns were given, with a diagram comparing them with a 30-mile thickness of rocks.

CORRESPONDENCE.

THE HIGH-LEVEL SHELLY CLAYS AND MR. MELLARD READE.[1]

SIR,—My "writings on the subject" are not so "numerous" by a long way as those of Mr. Mellard Reade, but I had hoped that they were at least tolerably clear as far as they went. I find, however, that my friend Mr. Reade has "completely misunderstood their tenour." He thinks I have made "strenuous endeavours to prove that high-level shelly beds do not exist." This would indeed be a waste of time on my part, in all cases where they were ordinarily well attested. No; freely admitting them in all such cases, the point of interest with me has been—How were they formed or deposited? Are they *in situ*, and do they indicate former levels of the sea? Mr. Reade seems to hold as a matter of course that they are and do; and he even suggests that if such shelly clays are found in one place, say at 1000 feet, it becomes "futile" and a "waste of time" to question whether a different bed (from all description) is found in another place at 500 feet! On the contrary, I hold that as some of these clays are known to have been transported, more of them than we imagine may be so; that therefore they do not necessarily indicate former levels of the sea; and that every case is to be judged of by its own evidence.

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[1] GEOL. MAG., March, 1897.

As regards Chapelhall, I certainly pointed out the slender evidence on which it rested, it being, so far as I know, quite exceptional in this respect; but I may say, on behalf of all the Committee, that it was a disappointment to them that the shelly clay was not found; for it was hoped that a careful examination of it would throw light on its origin and mode of formation. This would have been much more satisfactory to them than not finding it at all.

But Mr. Mellard Reade makes a far more important mistake than any regarding the purport of my poor papers. Referring to the suggestion that the Ayrshire beds have been laid down by a Frith of Clyde glacier, he says—"I can only point out that the hypothetical course of such a glacier does not correspond with that of any map I have yet seen which professes to give the lines of glacial flow in Scotland." Now, this is a point which should be easily settled. I suppose that the two best, most recent, and most authoritative maps of the ice-flow in Scotland are those by the Messrs. Geikie—Sir Archibald's sketch-map in his "Scenery of Scotland," 2nd edition, p. 248; and Professor James Geikie's of the British Isles in his "Great Ice Age," 3rd edition, p. 69. Both of these maps distinctly show the lines of ice-flow extending from the mountainous region around the heads of Loch Lomond, Loch Long, etc., across the opening of the Frith of Clyde, over the low grounds of Renfrewshire and Ayrshire, and curving out to sea in the neighbourhood of Ayr, as the West Highland ice came into contact with the ice from the Southern Uplands. And Sir Archibald Geikie expressly says, referring to the striations along the estuary of the Clyde—"These markings prove that the mass of ice moved southward from Loch Lomond, crossed the Clyde, passed over the hills of Renfrewshire, and crept down into the heart of Ayrshire, where it united with the ice that was streaming northward from the Southern Uplands" ("Scenery of Scotland," 2nd edition, p. 246). Professor James Geikie also notices the trend of the ice-markings in the lower reaches of the Clyde in similar terms "(Great Ice Age," 3rd edition, pp. 69, 70).

Now, will Mr. Mellard Reade kindly say what maps he has seen, "professing to give the lines of glacial flow in Scotland," which show them differently from the above? We may then come to understand how he does not appear to have seen Messrs. Geikies' maps, nor I those to which he refers.

GLASGOW, *March* 8, 1897. DUGALD BELL.

CYCADEOIDEA GIGANTEA, SEWARD: AN OMISSION.

SIR,—May I make use of your Magazine for the purpose of pointing out an unfortunate omission in a recent paper on a new Cycadean stem from Portland. In the last number of the Quarterly Journal of the Geological Society I gave a description of the

gnificent specimen of *Cycadeoidea*, which is now in the British
ıseum Fossil Plant Gallery.

Since this was published my attention has been called to the fact
ıt it is to Mr. A. M. Wallis, guide and quarryman, of Portland,
ıt we are primarily indebted for this valuable addition to the
.tional Collection. Mr. Wallis, on discovering the specimen, at
ce realized its scientific value, and took care that it fell into the
nds of those who appreciated its worth. I am much indebted
Mr. Strahan for calling my attention to this omission, and for
nishing me with the above facts. A. C. SEWARD.

AMBRIDGE, *March* 11, 1897.

THE AGE OF THE MORTE SLATES.

SIR,—If Dr. Hicks had only claimed that the Morte Slates are
ler than the Ilfracombe Beds, probably no palæontologist would
ve objected on the evidence at present available. But Dr. Hicks
ımed that the fossils proved the Morte Slates to be Silurian.

If Dr. Hicks considers the Oriskany Sandstone to be Silurian, his
ıws are as reactionary regarding the Devonian rocks of America as
ey are revolutionary regarding those of England.

In reference to the suggestion that I had not noticed that the
ecimen shown in figure 3 in the text did not belong to the same
lividual as the specimen shown in pl. x, fig. 6, I would ask
ıether the fossil fox on the staircase of the Geological Society and
fossil fox in the British Museum are to be called one specimen?
hould think most people would call them two specimens repre-
ıting one individual.

I am grateful to Dr. Hicks for emphasizing my argument that
diolopsis cannot be recognized without seeing the dentition. But
this is not shown in any of the Morte Slate specimens, why were
y referred to the typically Silurian genus *Modiolopsis*?

In regard to the identification of the big Brachiopod, I did not
er to the "characteristic ribbing," as I did not think the character
rth referring to. I have nothing to add or retract from my
narks about this fossil, and prefer to leave the question to the
imate decision of palæontologists. J. W. GREGORY.

OBITUARY.

CHARLES TOMLINSON, F.R.S.

BORN IN 1808. DIED FEBRUARY 15, 1897.

BY the death of Charles Tomlinson science has lost a man of
at learning, and who may perhaps be appropriately described
a Natural Philosopher of the old school. Although best known
his researches on physical and chemical subjects, as Lecturer
Experimental Science at King's College, and as one of the
ınders of the Physical Society; he was also a man of great
rary attainments, and one who had given a good deal of attention
subjects of Natural History, including Geology.

He joined the Geologists' Association soon after it was established
1859, and was for several years an active member, serving on

the "General Committee" in 1862. During this period he communicated several papers: (1) "On the Action of Heat on certain Sandstones of Yorkshire" (Proc. Geol. Assoc., vol. i, p. 50), when he drew attention to the road-metal used near Huddersfield, and to the custom of hardening the stone by the action of fire; (2) "On the Efflorescence which succeeds the action of Heat on certain Sandstones of Yorkshire" (ibid., p. 158); (3) "On the Plasticity and Odour of Clay" (ibid., p. 237), in which he observed that clay ceased to be plastic when deprived of its chemically combined water, and that plasticity and other properties depend upon variations in the attractive force of the molecules of matter according to the distances apart of such molecules. The peculiar odour of clay belonged only to impure clays, and chiefly to those containing oxide of iron. H. B. W.

THE REV. JOHN EDWARD CROSS., M.A., F.G.S.

(Prebendary of Lincoln).

BORN 1821. DIED FEBRUARY 28, 1897.

THE Rev. J. E. Cross (brother of Viscount Cross) was educated at Christ Church, Oxford, and was appointed to the curacy of Bolton-le-Moors in 1846. Three years later he became curate of Appleby, near Brigg, in Lincolnshire, and he was presented to the vicarage in 1856. In this quiet village he lived and laboured for thirty-five years, retiring in 1891 to Grange-over-Sands.

To geologists Mr. Cross is known as the author of an excellent paper on "The Geology of North-West Lincolnshire" (Quart. Journ. Geol. Soc., vol. xxxi, pp. 115–130. Appendix by R. Etheridge). In this work he described, for the first time in detail, the Jurassic formations from the Lower Lias to the Cornbrash, in the area bordering the south shore of the Humber between the rivers Trent and Ancholme. It was, as he remarked, "a corner of the land unknown to fame" until the discovery of the valuable iron-ore in the Lower Lias at Frodingham. Long and diligently had Mr. Cross worked, as shown by his careful record of facts, and the numerous fossils he had collected. Several new species of Mollusca were described by Mr. Etheridge. H. B. W.

MISCELLANEOUS.

NEW GEOLOGICAL SURVEY MAPS.—Attention was drawn in the GEOLOGICAL MAGAZINE for February, 1896, p. 96, to the General Map of England and Wales (on the scale of four-miles to one inch), which was in course of publication by the Geological Survey. We now learn that the hand-coloured edition of this useful map is complete, the fifteen sheets, including title and index of colours, all being published. We called attention to the fact that Sheet 12 of this map (London Basin and Wealden area) was issued last year at the greatly reduced price of 2s. 6d., *printed in colours.* We are glad to announce that three other sheets have now been similarly published, viz.: Sheet 6 (East Yorkshire), Sheet 9 (Eastern Counties), and Sheet 15 (Sussex Coast). The price is uniformly 2s. 6d.

G. M. Dawson

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IV.

No. V.—MAY, 1897.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists, No. 9: Dr. G. M. Dawson, C.M.G., LL.D., A.R.S.M., F.R.S., F.G.S., F.R.S.C., etc., Director of the Geological Survey of Canada.

(WITH A PORTRAIT, PLATE VII.)

DR. GEORGE MERCER DAWSON, F.R.S., whose portrait we present to our readers this month, is the son of Sir William Dawson, F.R.S., for many years Principal of McGill College, Montreal. Dr. Dawson was born at Pictou, Nova Scotia, August 2, 1849, and his early years were passed in Canada. After continuing his education in Scotland, he obtained his special training for a scientific career in the Royal School of Mines, Jermyn Street, of which he is an "Associate," and where he was also awarded the "Murchison" and "Edward Forbes" Medals. His first scientific appointment was as Geologist and Botanist to the British North American Boundary Commission, which in the seasons of 1873–4 marked out the International Boundary between the United States and the Dominion of Canada, for a distance of 800 miles in length. from the Lake of the Woods to the Rocky Mountains. Dr. Dawson devoted his observations more especially to the geology of the region traversed by the Commission, a large part of which was, at the time, quite unknown; and he gave an admirably succinct account of this and other features of the country, in his Report on the Geology and Resources of the Region in the vicinity of the forty-ninth parallel, published in 1875. This work clearly proved his capability as a field geologist, and in the same year he was appointed to the Geological Survey of Canada, with which he has since been connected, first as Assistant-Director under Dr. A. R. C. Selwyn, F.R.S., and afterwards as Director, on the retirement of Dr. Selwyn in 1894.

Dr. Dawson's geological work has been mainly carried on in the North-West Territories of the Dominion and in British Columbia. For many successive years he has been engaged in field-work in these wild and unsettled regions, where geological investigation is necessarily of a very arduous character, and much physical energy and endurance are required to cope with its hardships. In the course of his explorations, Dr. Dawson has visited such outlying regions as the Queen Charlotte Islands (1878), the northern part of

British Columbia and Peace River (1879), and the Yukon district (1887). Our present knowledge of the geology of these districts is largely from the observations carried out by Dawson and published in the voluminous Annual Reports of the Survey. Even in British Columbia, apart from the preliminary reconnaissance of Dr. Selwyn in 1871 and the work of the late Mr. J. Richardson on the Cretaceous strata of the coast areas, we are almost entirely indebted to Dr. Dawson for establishing the taxonomic relations of the rocks.

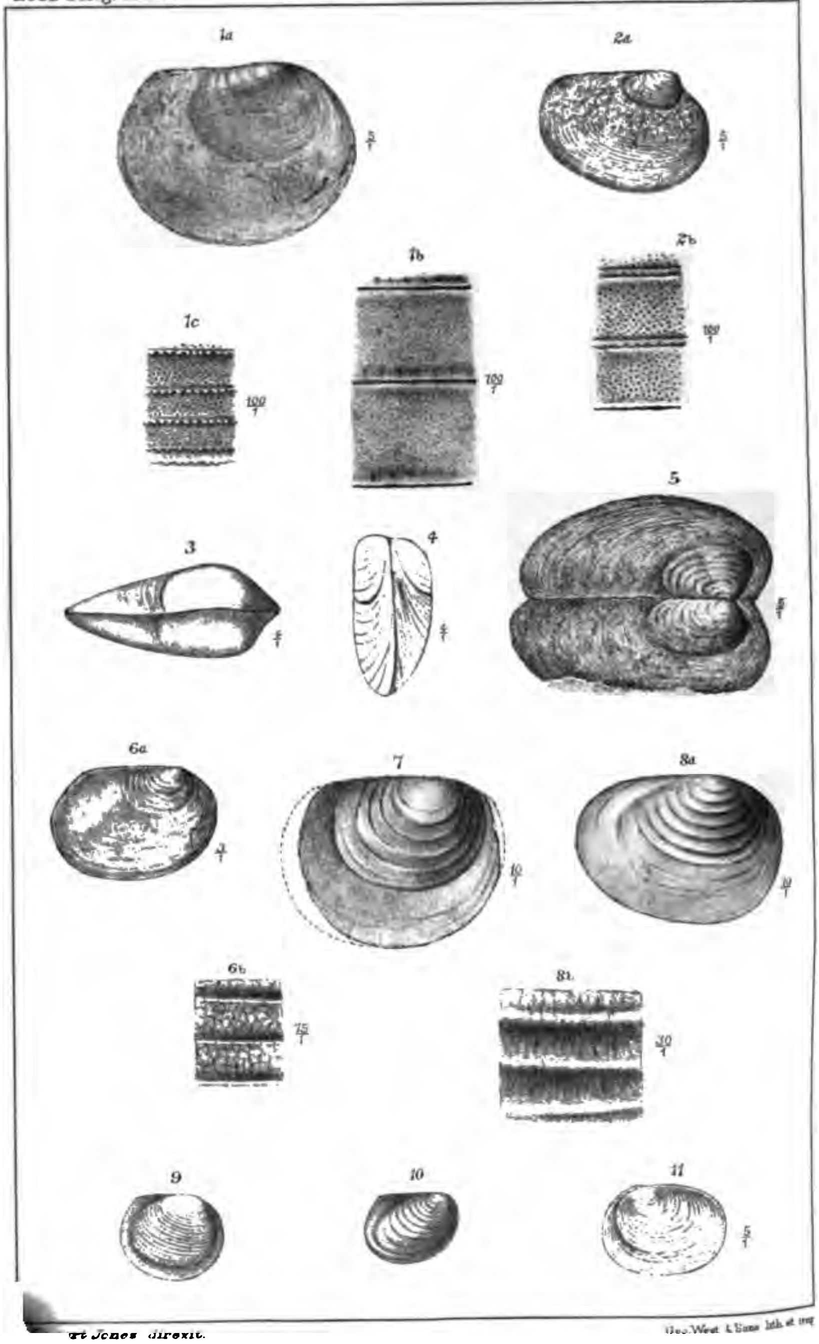
On the great plains of the North-West, Dr. Dawson has investigated more particularly the relations of the Cretaceous and the Laramie formations; and he has discovered the presence in the first-named formation in Southern Alberta of an important series of fresh-water rocks, the Belly-river group, which has not been noticed in the section of the Cretaceous worked out by Meek and Hayden on the Upper Missouri. In the adjacent Rocky Mountain region, another distinct group, the Kootanie, has been likewise recognized by Dr. Dawson as representing a period in the early Cretaceous.

Amongst the more ancient rocks of Canada, Dr. Dawson has ascertained that a great part of the Huronian formation in the Lake of the Woods district is composed of metamorphosed volcanic rocks. In British Columbia also, after a detailed examination of over 6,000 square miles of the interior plateau region, he has made known the existence of a thick series of mica schists and gneisses of presumed Archæan age, which are succeeded by Cambrian, Ordovician, Silurian, and Carboniferous strata. In the Cordilleran region of this province, he has further noted the occurrence of great deposits of contemporaneous volcanic rocks, in various stages of metamorphism.

At the other end of the geological scale Dr. Dawson has largely contributed to our knowledge of the glacial phenomena which in Canada are so strikingly developed. He was the first to describe the glacial origin of the Missouri Couteau; and in the interior plateau of British Columbia he has shown that at one period of the Ice Age, there was a confluent ice-mass the surface of which stood at a level of 7,000 feet above the sea, and that it must have been at least from 2,000 to 3,000 feet in thickness. He has further established the fact that the movements of the glacier ice in this region were not only to the south and south-east, and through the transverse valley and gaps of the coast-ranges to the ocean, but that it had also a northerly flow, and passed down the valleys of the Pelly and Lewes branches of the Yukon river.

With regard to the glaciation of the northern part of the Great Plains, Dr. Dawson maintains that the region, as a whole, has been submerged, and that floating ice has been the main agent in its glaciation, a view which is not in accord with that of the majority of American geologists.

Besides in the Canadian Survey Reports, Dr. Dawson's observations on this and other branches of geology, have appeared in the



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ESTHERIÏNA.

Quarterly Journal of the Geological Society, The Geological Society, the Transactions of the Royal Society of Canada, the Journal of Geology (Chicago), and in other American publications.

But Dr. Dawson's services to Science and the State have not been limited to Geology, for in 1891 he was appointed one of H. M. Behring Sea Commissioners, and made an extended cruise in that sea, investigating matters relating to the life and history of the fur-seal. He made use also of the opportunity to observe some interesting geological facts on the coasts and islands passed by, which were afterwards published in the Bulletin of the Geological Society of America (1894). Afterwards Dr. Dawson took part, as one of the Commissioners, in the Conferences held at Washington, and he subsequently assisted in the preparation of the British Case which was laid before the Behring Sea Arbitration Commission at Paris.

The value of Dr. Dawson's work has been duly recognized by geologists in this country as well as in Canada. The Geological Society of London awarded to him the Bigsby Medal in 1891, and in the same year he was elected a Fellow of the Royal Society. For his services on the Behring Sea Commission he also received the title of C.M.G. He served as President of the Royal Society of Canada in 1894, and his Presidential Address for that year embodies a careful review of what has been done, and what should be attempted, in the various branches of science in Canada. We are glad also to state that Dr. Dawson is to be the recipient this year of a gold medal from the Royal Geographical Society, a well-deserved honour.

The Geological Survey of Canada is fortunate in having so able a geologist as Dr. Dawson for its Director. In advancing our knowledge of the geology of that vast region and thereby contributing to its economic prosperity and development, Dr. Dawson will, we are confident, successfully carry forward the work of his eminent predecessors Logan and Selwyn. G. J. HINDE.[1]

II.—ON SOME FOSSIL ENTOMOSTRACA FROM BRAZIL.

By Professor T. RUPERT JONES, F.R.S., F.G.S.

(PLATE VIII.)

CONTENTS.

§ i. Introduction.
§ ii. *Estheriina*, gen. nov.
§ iii. *Estheriina Bresiliensis*, sp. nov.
§ iv. Remarks on some allied forms—*Estheriina Freysteini* (Geinitz).
§ v. ,, ,, ,, ,, *limbata* (Goldenberg).
§ vi. ,, ,, ,, ,, *expansa*, sp. nov.
§ vii. ,, ,, ,, ,, *astartoides*, sp. nov.

§ I. INTRODUCTION.

A collection of about twenty specimens of three or four kinds of shales, bearing several Estherian and small Molluscan fossils, was made by Mr. Joseph Mawson, F.G.S., Superintendent of the Bahia and San Francisco Railroad, several years ago, and presented by him to the British Museum. These are marked with the distances, in kilometres, from Bahia on the railway; and are provisionally referred by Mr. Mawson, some to the "Cretaceous" and some to the "Wealden" series. None are especially characteristic of these formations; but the strata containing them have been referred by Mr. C. F. Hartt to his "Bahian" Group of the Lower Cretaceous; equivalent, he thought, to the Neocomian of Europe. Mr. Hartt was one of the members of the Thayer Expedition, under Louis Agassiz, and published in his "Geology and Geography of Brazil" (1870) the details of his observations made along the railroad from Bahia to Alagoinhas on the San Francisco River (see pp. 349–372, and 555, 556).

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[1] Assisted by notes kindly supplied by J. F. Whiteaves, F.G.S.

These more or less fossiliferous beds rest on gneiss; and there are some overlying Tertiaries (?) at the eastern end of the Pojuca tunnel (p. 371).

Mr. Hartt's small sketch-map at p. 286 shows the bay, the town, and the railway. The last passes north-eastwardly from Bahia to Moritiba on the Rio Joannes; and thence northward to Matto de São Joãn, Pitanga, Pojuca, and Alagoinhas.

Dr. A. C. White, in his "Cretaceous Invertebrate Fossils" of Brazil, 1888, has described and figured many of the fossils collected by the Expedition under L. Agassiz, and in Mr. Mawson's collection there are a few of such as Dr. White treats of, but not from the same locality.

Mr. Hartt refers in a few instances to the occurrence of ***Estheria***: thus, at p. 349, referring to a group of shales, some black and laminated, and some lighter in colour, micaceous, and not well laminated, at Pedra Furada, not far from Monserrat, he says: "In this shale are to be found layers abounding in Entomostracan remains, of which the most interesting is an Estherian,[1] with its valves marked with concentric ridges, like an Astarte, and apparently new." Fish-remains are present. This shale at Pedra Furada is associated with a fossiliferous limestone, shales, sandstone, and conglomerate; continuous with the fossiliferous series, described by Allport,[2] at the Fort of Monserrat, Bahia.

Plantaforma, two miles from Monserrat, in a north-east direction (p. 347), is a hill of the same formation as that at Monserrat, and the same beds are exposed all the way from Plantaforma to the little bay of Periperi, about half a mile from Plantaforma; and where the railroad passes close to the water's edge (p. 354) there is exposed a section,[3] about 10 feet high, of shales and conglomerates, overlying a bone-bed and shales. Reptilian and fish-remains abound in the bone-bed (American Journ. Sci. and Arts, vol. xlviii, May, 1869).

Just below the station at Pitanga are shales and sandstones (section given at p. 368); in one shale, "C," is an Estherian like that at Pojuca tunnel, which traverses "Cretaceous" strata near Tertiary hills (view given at p. 371). In the cutting at the eastern entrance of the tunnel horizontal Tertiary (?) beds of soft brown sandstone occur, and in them "a bed, fifteen centimètres in thickness, of a yellow clay, decomposed shale (?), in which I have found a few Estherians"[1] (p. 371). The laminated blue-grey sandstone of the tunnel contained fish-remains and fragments of plants.

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[1] Probably the *Estheriïna Bresiliensis*, described further on.

[2] Quart. Journ. Geol. Soc., vol. xvi, 1860, pp. 263–8.

[3] *Estheria Mawsoni*, sp. nov. (to be described shortly), and some small Lamellibranchs appear to belong to this section, at kilometres 12–13 from Bahia.

Summary of the occurrences of Fossil *Entomostraca*, etc., collected by Joseph Mawson, Esq., F.G.S., from cuttings on the Bahia and San Francisco Railroad, Brazil, 1888.

	AT KILOMETRES FROM BAHIA.							BRIT. MUS. NOS.
Estheriïna Bresiliensis, gen. et sp. nov.	3·85, 4, 5	—	—	—	—	—	—	13, 37, 371, 372.
——— *expansa* ,,	—	—	—	—	—	83	—	L. 304·4.
——— *astartoides* ,,	—	—	—	—	—	83	—	L. 304·3, L. 304·4, L. 304·5.
Estheria Mawsoni,[2] sp. nov.	—	12–13	73	74	82	83	—	No. 31, L. 304, L. 304, L. 304·1, L. 304·2, L. 304·4, I. 466, I. 466, 6–10.
——— ——— var.[2]	—	12–13	73	—	—	—	84·5	
Cyprididæ[2]	—	—	—	—	—	83	—	L. 304·3.
Anodonta Harttii, White ...	—	12–13	—	—	—	—	—	L. 304.
——— *Mawsoni*, White ...	—							
——— sp.	—							
Arca, sp.	—							

§ II. ESTHERIÏNA, genus novum.

An Estherian carapace, the valves of which are not equally gibbose throughout, but more convex for a limited area in the umbonal region than lower down in the ventral region. Lines of growth are strongly marked on the convex portion; and are feeble, but numerous, on the flat marginal area, which varies in expansion in different species.

Three forms are observed in the Brazilian series under notice; and two published fossil forms seem to come into the same genus.

The zoological value of the umbonal convexity may be differently estimated from different points of view. It certainly seems to represent an exuberant growth of the early, compared with the later, parts of the animal and its valves. Although neither the "protoconch" in Gasteropoda and Cephalopoda, nor the "prodissoconch" in Lamellibranchiata, constitutes a classificatory feature in their genera or even their species, yet the persistent enlargement of the early part of the valves in bivalved Estherian Entomostraca is peculiar, and may be conveniently recognized as distinctive of a genus, or at least of a subgenus, in this group of Phyllopoda.

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[1] It is probable that *E. Mawsoni* (to be described subsequently) was seen by Mr. Hartt at Pitanga and Pojuca.

[2] To be described in another communication.

§ III. 1, Estheriïna Bresiliensis, gen. et sp. nov.

PLATE VIII, Figs. 1*a–c*, 2*a*, *b*, 3, 4, 5.

Valves subovate, with the earliest (umbonal) part of the valve very much more convex than the other part of the surface, and looking like an exaggerated growth of what had been prodissoconchal.[1] This neanic portion differs somewhat in colour, and probably in intimate structure to some extent. The outline of different specimens varies according to their stages of growth and sexual form; also by their having been subjected to pressure during fossilization. On the limited umbonal convexity, the lines of growth are marked by eight or nine concentric ridges, relatively coarse, and wide apart; whilst on the lower and outer, expanded, flatter, newer part of the valve the ridges of the lines of growth are thinner, much closer together (thirty or more), and neatly beaded with projections, probably the modified bases of earlier setæ. Near the edge of the valve this ornament becomes a mere crenulation on the close-set concentric ridgelets (Fig. 1*c*).

The interstitial ornament consists of a delicate and crowded pitting (Figs. 1*b*, 1*c*).

The valves are black, thin, and apparently chitinous, sometimes glossy on the boss or umbonal swelling; which, therefore, seems to be somewhat different in constitution; moreover, in some individuals it is of a brownish tint.

Fig. 1, a right-hand valve, much flattened and otherwise modified, is relatively the shortest and highest of the best specimens. It has a broad and blunt oval outline. In dark-coloured greenish-black fissile shale, with ferruginous staining on some bed-planes; some laminæ are sub-bituminous; some faces glazed and slickensided. With fish-remains.

Size.—Valve, length 6·4 mm., height 5 mm.; umbonal convexity, length 3·6 mm., height 2·4 mm. From a cutting on the Bahia and San Francisco Railroad at kilometre 5 from Bahia, near the viaduct.

Fig. 2, slightly crushed, has a subovate outline, much narrower posteriorly than Fig. 1. From the same dark shale, with fish-remains, at kilometre 4 on the railroad.

Size.—Valve, length 5·6 mm., height 3·2 mm.; umbonal convexity, length 1·6 mm., height 1 mm.

Besides this perfect valve there are on the same slab several imperfect valves and a pair in position, but not perfect; also three separate umbonal bosses, one of them shiny.

Figs. 1 and 2, differing by either variety, sex, or stage of growth, appear to represent the normal form.

Figs. 3 and 4 represent the edge view and the end view of the carapace, somewhat diagrammatically.

Fig. 5, from the same dark shale, a little nearer to Bahia (at 3·85 kilom. on the railroad), "near the junction of the Cretaceous with the Gneiss," shows two valves in apposition, umbo to umbo, opened out under pressure, but not to the fullest extent. In their height, modified by squeeze, these valves are much less than that of Fig. 1.

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[1] The prodissoconch is more or less persistent in some bivalved Molluscs, as *Sphærium*, *Pisidium*, *Ostrea*, *Avicula*, etc.

Size.—Valve, length 7 mm., height 2·6 mm.; umbonal convexity, length 2·8 mm., height 1·4 mm.

There are several other specimens of these black and shining valves of approximately similar shapes, but more or less altered by pressure, both scattered on the dark-coloured shale from "kilom. 4," and lying thickly together in the dark and almost bituminous shale from "kilom. 5."

Remarks on some Allied Forms.—A somewhat similar feature (namely, the umbonal convexity) occurs in H. B. Geinitz's "***Estheria Freysteini,***" from the Coal-measures of Saxony. A large portion of the valve is raised in a persistent convexity near the umbo (10 mm. long and 8 mm. high, in a valve 12 × 10 mm.), leaving a flattened marginal area, much narrower than in the Brazilian specimens under notice. There is also some indication of this characteristic feature in Goldenberg's "***Estheria limbata.***" For the purpose of comparison, concise descriptions of these two forms are here given.

§ IV. 2, Estheriïna Freysteini (Geinitz), 1855 and 1876.

PLATE VIII, Figs. 9, 10.

Cardinia Freysteini, Geinitz, Versteinerungen der Steinkohlenformation in Sachsen, 1855, p. 2, pl. xxxv, figs. 7*a*, 7A. ***Estheria Freysteini,*** Geinitz, Sitzungs-Berichte der naturwissensch. Gesellschaft Isis in Dresden, Jahrgang 1879, p. 10, pl. i, figs. 2*a*, 2A.

Each of these has a straight hinge-line, and a large portion of the valve near the umbo is very much more convex than the rest of the surface.

The specimens of which figs. 7*a*, 7A were given in 1855 were from the Coal-shale of the Scherbenkohlflötze of Oberhohndorf, near Zwickau. Of these there were a few examples measuring 13 × 11 mm.

That one figured as 7A appears to measure—

Size.—Valve, length 15 mm., height 13 mm.; umbonal convexity, length 11 mm., height 9 mm.

There are 19 or 20 strong concentric ridges on the convex part, and 9 or 10 delicate lines traceable on the flat part of the valve.

The "***Estheriæ***" figured in 1879, figs. 2*a*, 2A, came from the Upper Coal-formation, Carl-Schachte, near Lugau, Saxony; and fig. 2*a* appears to measure—

Size.—Valve, length 12 mm., height 10 mm.; umbonal convexity, length 11 mm., height 9 mm.

In some pencil drawings of the same species, kindly supplied by Dr. H. B. Geinitz, the measurements are—

Size.—Valve, length 12 mm., height 10 mm.; umbonal convexity, length 10 mm., height 8 mm.

There are, it seems, 12 or 13 concentric riblets on the valve; and, of these, 6 or 7, on the postero-dorsal area, appear to be delicate lines continuous with some of the coarser ridges of the convexity.

This form as figured in the "Isis," 1879, is obliquely ovate (Pl. VIII, Fig. 10) in general outline. In the "Verstein. Sachsen," 1855, it is shorter and subcircular in outline (Fig. 9). Possibly a sexual difference.

In figs. 2*a*, 2A (1879) the umbonal convexity is subovate in outline; and the flat marginal area is much narrower in front than behind (Fig. 10). The flat margin is narrow and less distinct than in figs. 7*a*, 7A (1855). In the latter (Fig. 9) the umbonal convexity is more nearly subcircular in outline, and the flat marginal area broader and more distinct than in figs. 2*a*, 2A (Fig. 10). The strong concentric ridges on the convex portion and the very delicate lines on the flat parts are well shown, especially in fig. 7A.

§ V. 3, ESTHERIÏNA LIMBATA (Goldenberg), 1877.

PLATE VIII, Fig. 11.

Estheria limbata, Goldenberg, Fauna Saræpontana Fossilis, Heft 2, 1877, p. 43, pl. ii, figs. 12 and 14.

The figures of this "*Estheria limbata*," from the Coal-shale near Wemmetzweiler in the Saarbrücken Coalfield, indicate a similar unusual convexity at the umbo of the valve. This form appears to have about 24 concentric riblets, with square-celled interspaces. Of these lines of growth, 15 are strong and prominent on the umbonal region, which is more convex than the rest of the surface; the other concentric riblets are smaller and closer together, "mere lines," on the narrow and flat marginal area or border, whence originated the name "*limbata*."

Fig. 12, magnified six diameters, appears to represent a specimen measuring as follows—

Size.—Valve, length 4·0 mm., height 3·0 mm.; umbonal convexity, length 3·0 mm., height 2·5 mm.

Fig. 14, magnified fourteen diameters, represents a specimen—

Size.—Valve, length 3·6 mm., height 2·4 mm.; umbonal convexity, length 2·4 mm., height 2·0 mm.

It is evident the Brazilian specimens described above, with the umbonal swelling or prodissoconchal boss, differ from both *E. Freysteini*, Geinitz, and *E. limbata*, Goldenberg, by the dorsal convexity having a much smaller area in relation to the size of the valves, and by the other part of the valve in the Brazilian form being expanded to a much greater extent. In its general outline the latter differs from the foregoing European species, although approaching in shape to *E. Freysteini* as figured in the "Isis," 1855 (Pl. VIII, Fig. 9).

If we take advantage of G. O. Sars' careful researches in the life-history of some Estherian forms,[1] we may see that such a persistent swelling near the umbo, as we have in the hump-backed fossils here mentioned, may be said to represent the partly developed test, in its early stages of existence, not so much in the larval

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[1] Christiania Vidensk.-Selsk. Forhandl. 1887, No. I; *Cyclestheria Hislopi*, p. 8 et seq., pls. i and ii, vii and viii. Archiv. Math. og Naturw., vol. viii, pt. 1, June, 1896; *Estheria Packardi*, pp. 1–27, pls. i-iv.

(brephic) form as in the post-larval (neanic) stages. Looking at the fossils above mentioned in this light, it seems that *E. Bresiliensis* shows valves of advanced adult growth (having nearly 40 lines of growth) with a prodissoconchal protuberance usually little less than half the size of the valve. The other two forms (*Freysteini* and *limbata*) are also adults (with about 30 lines of growth), and each exhibits an umbonal swelling, having an area little less than that of the whole valve.

This umbonal swelling does not constitute merely a specific difference; it points in all probability to subgeneric or even to generic distinction, as much as the characteristic features of the Triassic *Estheriella*.

Although, without indications of the limbs and soft parts, its separation from *Estheria* can be only provisional, yet it seems to be expedient and useful to recognize this hump-backed form as typical of a genus, with the name of *Estheriïna*.

§ VI. 4, Estheriïna expansa, sp. nov.

PLATE VIII, Figs. 6*a*, 6*b*.

A small, obliquely oval-oblong, flattened, yellowish, and filmy valve exhibiting two different areas of surface; namely, a small subtriangular portion near the umbonal end, bearing a few strong concentric ridgelets, and a larger expanded flattened part of the valve, smooth and shining, with traces of concentric markings and irregular wrinklings. A faint reticulation of irregularly subquadrate meshes is discernible between the riblets on the umbonal region (Fig. 6*b*).

Size. — 7·6 × 5 mm. The umbonal convexity measures 3·0 × 1·6 mm.

In the usual soft light-brownish shale, from a cutting at kilometre 83 from Bahia, between Pojuca and San Thiago.

This is evidently an *Estheriïna*, but different from both *E. Bresiliensis* (Figs. 1–5) and *E. astartoides* (Figs. 7 and 8), agreeing more with the former than the latter. It is interesting to find the same genus (*Estheriïna*) represented at localities fifty miles apart, at 4–5 kilom. (Pedra Furada) and at 83 kilom. from Bahia (near Pojuca).

§ VII. 5, Estheriïna astartoides, sp. nov.

PLATE VIII, Figs. 7, 8*a*, 8*b*.

A small, semicircular, somewhat gibbose carapace; swollen, thick, and marked with strong concentric ridgelets on the moiety of each valve near the umbo, and flattened into a broad, marginal area on the free borders, with faint concentric lines.

A specimen (Fig. 7) that has preserved its normal form measures 3 × 2·6 mm., and the umbonal convexity 2 × 1·5 mm.

Another specimen (Fig. 8*a*) measuring 3 × 2·6 mm. is subovate, having probably been modified by pressure. The convex part has lost its distinctness from the flatter portion for the same reason. Feeble traces of some transverse lineation in the larger concentric interstices are recognizable (Fig. 8*b*), possibly modified by minute parallel fissures. When crushed obliquely the ridges have been compressed into sharp thin ledges, and pushed back one on another.

The umbonal part is like a small *Astarte*, such as *A. sulcata*, Da Costa, and another small species occurring in these same Brazilian strata, *A. agraria*, A. C. White.[1] The boss is sometimes found by itself; the flatter, thin, outer, marginal, flange-like portion having been shifted away. In the usual soft light-brown shale; from a cutting at kilom. 83 from Bahia between Pojuca and S. Thiago, with *E. expansa*, and between Sargiva and Pojuca.

EXPLANATION OF PLATE VIII.

FIG. 1.—*Estheriïna Bresiliensis*, gen. et sp. nov.: *a*, right-hand valve, × 5; *b* and *c*, ridges and interstitial ornament, × 100—one (*b*) near the middle of the valve, the other (*c*) low down near the ventral margin. Brit. Mus. Nos. 13, 37, 371, 372.

FIG. 2.—The same species: *a*, right-hand valve, × 5; *b*, ornament, × 100.

FIG. 3.—The same species: dorsal aspect, × 4.

FIG. 4.—The same species: front end, × 4.

FIG. 5.—The same species: the two valves lying open, × 5.

FIG. 6.—*Estheriïna expansa*, sp. nov.: *a*, right-hand valve, × 3; *b*, surface ornament, × 75. Brit. Mus. No. L. 304·4.

FIG. 7.—*Estheriïna astartoides*, sp. nov.: right-hand valve, × 10. Brit. Mus. No. L. 304·3, L. 304·4, L. 304·5.

FIG. 8.—The same species: *a*, right-hand valve, slightly distorted, × 10; *b*, surface ornament.

FIG. 9.—*Estheriïna Freysteini* (after Geinitz, 1855): right-hand valve, nat. size.

FIG. 10.—The same species (after Geinitz, 1879): right-hand valve, nat. size.

FIG. 11.—*Estheriïna limbata* (after Goldenberg, 1877): left-hand valve, × 5.

III.—ON A HORNBLENDE-PICRITE FROM THE ZMUTTHAL (CANTON VALAIS).

By CATHERINE A. RAISIN, B.Sc.

WHILE staying at Zermatt in the summer of 1894, I searched among the boulders from the Zmutt glacier for several types of rock, which, as suggested to me by Professor Bonney, were likely to occur. I am further indebted to him for kindly giving me his help and opinion on several questions while I was writing this note.

One specimen which I collected proves to be rather different from the rocks recorded from that district, and has points of interest. The boulder was rather large (roughly about 2 feet across), and it lay by the side of the path, on the right bank close to the glacier near its termination, where the moraine material is thickly heaped upon the ice, and many boulders are strewn along the side.

The rock is blackish, with scattered specks of a soft white mineral, and with glittering cleavage surfaces of crystals which appear lustre-mottled. It attracted my notice from its resemblance to a picrite, and especially to the Penarfynydd rock.

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[1] The subtrihedral shape of these Astartes is wanting here, and they are too large. *Astarte agraria* measures 20 mm. x 19 mm., and the thickness of the carapace is 12 mm. *A. cælata*, Münster, about 5 mm. long; *A. planissima*, Forbes, has definite Molluscan characters, and is about 12 mm. long.

On examination with the microscope the olivine is seen to be fresh-looking, forming the usual rounded grains with reticulate structure, where alteration is just beginning. At one part of the slice, around the olivine and separated from it by a sharp, sometimes crystallographic boundary, is clear unaltered hornblende, often extending as a large crystal enclosing many grains. It is brownish, dichroic, exhibits low brownish tints with crossed nicols, and well-marked cleavages along which deeper-coloured rhomb-shaped inclusions are often ranged — examples of Professor Judd's schillerization enclosures. These apparently have a tendency to be formed along an internal zone of the crystal.

At another part of the slide, the olivine is imbedded within a mineral generally colourless, much of which is undoubtedly augite.[1] Sometimes, however, a faint dichroism, a brownish colour, and characteristic lattice cleavage are exhibited, and it seems as if the augite is changed to hornblende.[2] At one part a bordering mineral similarly related to the olivine, but having a close fibrous actinolitic structure, like the pilite of Becke, may be a further modification of the original pyroxene.

The third important constituent (forming the white specks seen macroscopically) is a mineral, now mostly a dusty-looking opaque substance, but often changed at least at the exterior to serpentinous or some non-polarizing aggregate. Remains of one good cleavage and sometimes of a cross cleavage are well marked, and the mineral seems to be decomposing bastite or steatite. The rhombic pyroxene apparently developed late, filling up the interspaces between the hornblende. At one side of the slice a large crystal of fresh-looking enstatite[3] surrounds the olivine, and is intercrystallized with some of the bordering hornblende and even with some of the decomposed bastite.

It thus seems as if the monoclinic was the first of the pyroxenes, starting and forming on the edge of pre-existent olivine, but was in some cases speedily followed by the orthorhombic pyroxene. Thus, occasionally a large crystal of augite or hornblende occurs, lustre-mottled by the olivine, but the extended crystal may be represented only by rims, and bastite may fill up much of the space.[4] This at places gives to the latter the aspect of an inclusion, but its form shows that it followed the olivine and was not a contemporaneous formation.

The spinellid is pleonaste of a rather bright green colour, often in partly rounded grains, occurring sometimes within hornblende, as if moulded along the cleavage planes, and sometimes within serpentine. Pyrites occurs within the enstatite and the hornblende.

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[1] It is usually not dichroic, exhibits well-marked cleavage planes, and the high extinction angle of augite.

[2] As described by Professor Bonney, "On the so-called Diorite of Little Knott (Cumberland), with further remarks on the Occurrence of Picrites in Wales": Q.J.G.S. 1885, vol. xli, p. 520.

[3] The enstatite has close parallel cleavages which almost seem to form a repeated twinning, but this (examined with a high power) is seen to be an effect of a large number of elongated vesicular-looking enclosures, which are probably negative crystals formed along gliding planes. Cf. Prof. Judd, Q.J.G.S. 1885, vol. xli, p. 354.

[4] This may possibly indicate a local deficiency of lime in the magma, a thing not surprising, as peridotites are often ill-mixed rocks.

As in other picrites, certain minerals act as a groundmass, which varies even in one slide. The order of consolidation seems to have been—(1) olivine, (2) pleonaste, (3) augite and hornblende or enstatite, (4) a second variety of enstatite, now steatitic.

The rim bordering the olivine grains is occasionally penetrated by serpentine or chrysotile. This is deposited apparently along cleavage planes in narrow spaces which extend beyond as forked branching canals, suggesting a more irregular fracturing. The canal part reminds us somewhat of an 'eozoon' structure, as was remarked by Professor Bonney in noticing a similar development in a troctolite.[1] It is also like the structure in gelatine figured by Professor Sollas,[2] and similar to specimens which I have obtained in some simple experiments. In the last case, at least, the cause seems to be a cracking of the material, the cracks often having certain more regular cavities as starting-points. Similar canals are found in the slide here described along rather regular cleavage planes in part of a crystal which resembles bastite, and some of the dusty decomposed patches of that mineral resolve themselves in a thin slice under a high power into a system of what look like very fine tubules. In a gabbro from Portsoy, Professor Judd describes radiating cracks as caused by the "expansion of the olivine during its hydration," and injected with serpentine.[3] These cracks are generally well seen in the troctolites, and Mr. Harker refers to this character in the Lleyn picrite.[4] In the Zmutthal specimen, a definite and limited rim around the olivine seems to be penetrated, thus producing a more regular form of a canal system.[5] As to the origin of the structure, while the expansion from hydration may have acted as one cause, it seems probable that the mode in which the mineral originally crystallized (possibly from its narrow area) developed certain planes of weakness, not at first recognizable, along which corrosion or fracture could afterwards act.

The boulder which I am describing is probably connected with other rocks from this neighbourhood, although it is distant from them. One of these contains unchanged olivine—the olivine-gabbro of the Matterhorn[6]—in which the occurrence of green pleonaste has been noticed. In that rock, however, felspar is present, described as plagioclase and idiomorphic. In the boulder, the dusty-looking or opaque white substance clearly is interstitial, and is now steatite, a decomposition product of a rhombic pyroxene. The specimen appears to be nearest to the group of the picrites, to the form of that rock not containing felspar. It is somewhat intermediate between the typical augite-picrite and the variety distinguished by Professor Bonney as hornblende-picrite, and it has a likeness to the Penarfynydd rock.[1] So far as I am aware, it has not been recognized *in situ* in the Zmutt district, and it will be interesting if any climber in that neighbourhood should track it to its home. The boulder being large, it most probably came directly from some of the neighbouring heights, possibly from the western side of the Matterhorn, gabbro, according to the Swiss map, occurring from the watershed down at intervals to the neighbourhood of the Zmutt glacier. This hornblende-picrite is interesting as another variety of the basic igneous rocks, varying from serpentine to gabbros, which form a widespread group, extending at least from the Saas Valley to the Val d'Hérens.

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[1] "On Bastite Serpentine and Troktolite in Aberdeenshire": GEOL. MAG. 1885, Decade III, Vol. II, p. 444, note.

[2] Trans. Royal Irish Acad., vol. xxix, pp. 462–3.

[3] Q.J.G.S. 1886, vol. xlii, pp. 94–5, pl. vii, fig. 7.

[4] Q.J.G.S. 1888, vol. xliv, p. 455.

[5] In my specimen of the Penarfynydd picrite, which I collected in 1885, the olivine contains, sometimes at the edge, clusters of needle-shaped structures either parallel or radiating in a stellate form, the needles in both cases suggesting minute fissures starting from a centre. At places the parallel bundles seem to be connected with a fibrous chrysotile development

[6] T. G. Bonney, "On some specimens of Gabbro from the Pennine Alps": Min. Mag., April, 1878. T. G. Bonney, "Petrological Notes on the Euphotide or Saussurite-Smaragdite Gabbro of the Saasthal": Phil. Mag. 1892, vol. xxxiii, ser. 5, p. 237. R. W. Schäfer, Tschermak Min. and Petr. Mitth. Wien, Bd. xv, Heft. 1 and 2, 1895, p. 132.

IV.—On the Subdivisions of the Carboniferous Series in Great Britain, and the True Position of the Beds Mapped as the Yoredale Series.

By Wheelton Hind, M.D., B.S.Lond., F.R.C.S., F.G.S.

(*Concluded from the April Number*, p. 169.)

THE earlier part of this paper is devoted to a short epitome of the stratigraphical evidence that the Yoredale rocks of Wensleydale are only the equivalents of the upper part of the Carboniferous Limestone, and that the so-called Yoredale Beds of South Yorkshire, Lancashire, and Derbyshire are an entirely different series, which occupy a position above the Carboniferous Limestone. After all, the important point is the palæontological evidence, which, to my mind, is absolutely conclusive.

On comparing the Molluscan fauna of the limestones and shales of the Yoredale Rocks of Professor Phillips with that of the Carboniferous Limestone of Derbyshire, it is at once seen that they are practically identical. In the list of fossils given in the Appendix to the Geological Survey Memoir on the country round Mallerstang,[2] 110 named species of corals, echinoderms, annelids, crustaceans, polyzoa, and mollusca are enumerated, the great majority of which are common to the Yoredale Series and Great Scar Limestone. But no species occur which are peculiar to the upper beds, and which do not occur in the massif of Carboniferous Limestone in one locality or another. On palæontological grounds, therefore, no distinction can be drawn between the Yoredale Series of Wensleydale and the main mass of Carboniferous Limestone, though it would not have been surprising, considering the differences of lithological character in the deposit, if such had been the case. Not only do the Yoredale Rocks of the Wensleydale area contain no distinctive fossils peculiar to themselves, but many species recur again and again in beds separated from each other by many feet of different strata, in which often plant beds occur and at times well-marked seams of coal, proving that terrestrial conditions obtained between deposits containing a similar fauna. There is no possibility, thanks to the nature of the ground, that the series of limestones are only one bed, repeated by a succession of folds; and the only alternative is, that owing to an unsuitable environment the fauna migrated and lived on in an outside area, ready to return when suitable conditions obtained. This was, of course, Barrande's theory for his "colonies." for the truth of which it would appear that the Carboniferous rocks afford abundant evidence, and the series of Carboniferous rocks in Scotland give a good example.

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[1] Cf. T. G. Bonney in Geol. Mag. 1880, p. 208. A. Harker, loc. cit.

[2] Explanation of Sheet 40, Geological Survey.

In Scotland, beneath the Coal-measures, there is a long series of alternating beds of sandstones, shales, limestones, and coals as an upper division, and the Calciferous Sandstone Series as a lower division, consisting of shaly clays and argillaceous limestones, oil shales and sandstones. The fossils characteristic of the Carboniferous Limestone of England are found throughout the upper series in those beds which are of marine origin, and occasionally in thin bands in the Lower or Calciferous Sandstone Series. In the beds of this series on the Fifeshire coast, Mr. J. W. Kirkby, of Leven, has enumerated no less than eighteen such marine horizons distributed chiefly in the upper and lower portions of 4000 feet of strata ("On the Zones of Marine Fossils in the Calciferous Sandstone Series of Fife": Quart. Journ. Geol. Soc. 1880, vol. xxxvi, p. 559). One hundred and fifty-two species are enumerated, of which only seven appear to be new and therefore, as far as is known at present, peculiar to the series; but a few others belong to fresh- or brackish-water beds.

It is curious to note that between 500 and 2280 feet no marine bands have as yet been discovered, and only four occur in the first 600 feet; the 1780 feet of intervening beds being composed of repeated alternations of sandstones of various colours, shales, marls, and ironstone bands, in several of which, but chiefly in the argillaceous beds, plant-remains are fairly plentiful.

It is evident, too, that the Carboniferous Limestone fauna did not die out with the close of that period, even as expressed in the rocks of the Derbyshire-Yorkshire area; for, although absent from the strata for intervals of time represented by many hundred feet of deposit, there are occasional recurrences of certain typical fossils of that fauna in certain widely separated localities at different horizons.

Mr. J. Ward has shown three bands with a marine fauna to exist high up in the North Staffordshire Coalfield, two of which contain several well-known Carboniferous Limestone species, the third only *Lingula squamiformis*. I make no mention of the marine bands containing *Goniatites Listeri* and *Aviculopecten papyraceus*, as these shells do not belong to the fauna contained in the limestones. At Coalbrookdale ***Spirifer bisulcatus*** and ***Productus scabriculus*** occur with other marine shells in the Penneystone Ironstone of the Coal-measures, which, however, do not occur in the Carboniferous Limestone.

In a bed of shale containing calcareous bullions, situated above a gannister-like sandstone, some little distance below the third bed of Millstone Grit on Congleton Edge, is a fairly rich fauna, containing, amongst others, ***Productus*** (four species), ***Spirifer, Athyris, Orthis, Streptorhynchus, Chonetes, Terebratula, Discina,*** and ***Lingula,*** all of which are found in the limestone, but are absent in all the intervening beds. It is difficult to arrive at any satisfactory conclusion as to the whereabouts of this Carboniferous sea in which the limestone fauna survived, and it is questionable if a discussion of the matter would be productive of any benefit.

The proper fauna of the beds between the Millstone Grits and the Carboniferous Limestone in the Yorkshire-Derbyshire area is a very typical one, though not peculiar, in any particular, to this horizon; in fact, it is identical with the fauna which is found in the marine beds of the Gannister Series of the Lower Coal-measures. The evidence for this fact has been lately much increased by the collections of Messrs. Holroyd and Barnes, in the beds exposed below the Millstone Grits in the valleys round Marsden and Saddleworth, and from the beds passed through in the London and North-Western Railway tunnel under Standedge Moor. I have been over the ground with these gentlemen, and have had the opportunity of gathering the fossils myself as well as of studying the fine series that they have collected during the last few years. The fauna is, taken as a whole, very similar to that which has always been considered characteristic of the Gannister Series of Lancashire, several species being identical with those found in the nodules of the roof of the Bullion Coal. Very few species, indeed, if any, are common to it and the Mountain Limestone fauna; but the three genera ***Carbonicola, Anthracomya,*** and ***Naiadites,*** which are so frequent in the Coal-measures, are all represented, the former by at least four well-marked species; and the shells themselves cannot be in any way distinguished from those occurring in the Coal-measures. It may be therefore emphatically stated, that the fauna of the shales which are situated below the Millstone Grit in South Yorkshire is totally distinct from that which characterizes the shales and limestones of Wensleydale.

Though not known to be so rich in species, the shales of Derbyshire and North Staffordshire contain a similar fauna, several species of ***Goniatites,*** amongst which ***G. reticulatus*** is conspicuous, ***Aviculopecten papyraceus,*** and ***Posidoniella lævis*** occurring at several horizons. In Cheshire, however, on Congleton Edge, situated some 200 feet below the base of the Millstone Grit, here represented by the third, Rivelin or Roaches grit, is a bed of black shales in which are layers of calcareous nodules, which overlies a hard, fine, gannister-like quartzose rock. These concretions contain a rich fauna, which, although peculiar with regard to its Lamellibranchs and Gasteropods, has a plentiful Brachiopod fauna, consisting of typical Carboniferous Limestone forms. The following species have been collected in this quarry by myself:—

Terebratula hastata.
Spirifer glaber.
,, bisulcatus.
Athyris planosulcata.
,, ambigua.
Orthis resupinata.
Streptorhynchus crenistria.
Productus semireticulatus.
,, longispinus.
,, cora.
,, scabriculus.
Chonetes Laguessiana.
Discina nitida.
Lingula mytiloides.

LAMELLIBRANCHS.

Myalina peralata.
Modiola transversa (Hind).
Nucula gibbosa.
,, æqualis.
Edmondia, sp.
Sanguinolites, sp.
Posidoniella semisulcata (Hind).

There are also several forms of *Goniatites*, *Nautilus*, *Orthoceras*, with Gasteropoda and Crustacean remains, including *Dithyrocaris testudineus*. It is to be noted that, although the Brachiopoda are Lower Carboniferous forms, the Lamellibranchs are peculiar.

Many fossils have been obtained from the shales in the neighbourhood of Todmorden, several of which are to be seen in the Manchester Museum, Owens College. This fauna is a very singular one, and remarkable for the number of species.

The nomenclature and lists given by authors are, however, not to be trusted, most of the forms having been named by Captain Brown, and the vast number of the names are only synonyms. Still, several forms of *Posidoniella* are present, of which, after an examination of all the types, fortunately preserved at Owens College, I recognize *Posidoniella lævis* (Brown), *P. minor* (Brown), *P. Kirkmani* (Brown), *P. variabilis* (Brown), *P. subquadrata*, sp. nov., *Aviculopecten papyraceus*, Sow., *A. fibrillosus*, Salter, *Nucula gibbosa*, Fleming, *N. æqualis*, Sow., *Goniatites reticulatus*, *G. stenolotus*, *G. carbonarius*, *G. Listeri*, and at least two new species.

J. W. Davis quotes ("West Yorkshire") four species of *Nautilus*, ten species of *Goniatites*, fourteen species of *Orthoceras*, together with a very rich Gasteropod fauna, from the same bed. I am not well enough acquainted with these groups to say anything as to the value of the large number of species here enumerated, but the common Mountain Limestone species are all conspicuously absent.

With regard to the Brachiopods, only three are mentioned by authors—*Orthis resupinata*, *Productus Martini*, and *P. antiquatus*, Gibson; but I have not seen these specimens, and from the curious nomenclature nothing can be said at present as to what species occur at Todmorden; still, the essential fact remains that, on the whole, Brachiopoda are conspicuously absent.

The shales of Flasby are credited with a long list of *Goniatites*, among which are *G. Listeri*, *G. Longthorni*, and *G. reticulatus*, all of which occur in the Gannister Series of the Lower Coal-measures.

Viewing, therefore, as a whole the fauna of these shales, it cannot but be noted that it is totally different from that of the Mountain Limestone, and also of the Yoredale Series of Wensleydale; and the question at once arises as to the correctness of applying the term Yoredale to them, seeing that they differ so essentially, both lithologically and palæontologically, from those beds to which the term was originally applied. There is in these beds an absence of the limestones which are so characteristic of the series in Wensleydale, and this may at first sight appear to account for the difference in the faunas; but, as a matter of fact, some of the shales in Wensleydale are far richer in organic remains than the limestones, and these remains are typically those which occur in the great mass of limestone.

Indeed, if my contention be correct, that the Yoredale Series of Wensleydale is the homotaxial equivalent and also the chronological representative of the massif of limestone so typical of Derbyshire, then the black shales of North Staffordshire, Derbyshire, and South Yorkshire belong altogether to a higher horizon and are not in any way the equivalents of any beds of the Yoredale Series. If stratigraphical division be necessary, the only reliable data, in the absence of unconformity or some well-marked change of lithological character, are of a palæontological nature; and this evidence points undoubtedly to a closer biological connection between the so-called Yoredale Beds of Derbyshire with those above, and the Yoredale Beds of North-West Yorkshire with those below. It appears to me that the so-called Yoredale Beds of Derbyshire and Yorkshire should really be included in the Millstone Grit Series, as they contain a very similar fauna and flora, and, moreover, certain very well developed sandstones, often extremely difficult to separate on lithological grounds from true grits.

There are three very different molluscan faunas in Carboniferous rocks, and I have yet to be convinced that they are actually intermingled in the same bed, though there can be no doubt that they overlap each other somewhat.

No. 1.—The Coal-measure fauna, rich in fish-remains, with the molluscan genera *Carbonicola*, *Anthracomya*, and *Naiadites*; essentially a fresh-water fauna.

No. 2.—The Lower Coal-measure and Grit fauna, the Gannister and Grit Series, largely marine, but littoral; *Aviculopecten*, *Posidoniella*, *Goniatites*, *Orthoceras*, *Nautilus*, and peculiar Gasteropoda.

No. 3.—The Limestone fauna, essentially marine, rich in corals, Polyzoa, very rich in Brachiopods; with *Pecten*, *Avicula*, *Edmondia*, *Sanguinolites*, and many other genera of Lamellibranchs, Gasteropods (*Euomphalus*, *Pleurotomaria*, *Murchisonia*, *Loxonema*, etc.), and Cephalopoda, Corals, Crinoids, and Fish-remains, many of these being peculiar to certain beds.

In a few localities, as at Congleton Edge (vide p. 207), we find a curious fauna, which would appear to be a mixture of a few of the Brachiopoda of the Limestone with a fauna on the whole somewhat approaching that which obtained in the middle of the Carboniferous Series; but here, as at Coalbrookdale, it is only the Brachiopoda of the lower beds which are present, and this family appears to have comprised the hardiest and most able of all forms of life to assimilate themselves to altered conditions.

These differences are due to bathymetric conditions, and the overlapping of the faunas to a return to conditions suitable for each group of organisms.

In the North Midlands the fossil flora is abundantly present, with the first fauna: present only in the sense of occurring in beds intercalated with the molluscan-bearing beds, except in the roof of the Bullion Coal, where there is drifted woody material in abundance. The flora is practically absent in the beds containing the lower fauna.

In Northumberland and Scotland the peculiar fauna characteristic of those shales which occur below the Millstone Grit in South Yorkshire is absent, although one or two species are quoted, but no reliance can be placed on the nomenclature of the Goniatites at present.

Aviculopecten papyraceus, so characteristic of these beds, is quoted by John Young ("The Carb. Foss. of the West of Scotland," p. 47) as rare, and it is noted by the Palæontologists of the Survey as occurring in shales some distance above the Ell coal (Wishaw district), and in the shale above the Calderwood cement-stone (E. Kilbride district: Mem. Geol. Surv. Scotland, Explanation of Sheet 23) is very much lower down, but in neither case do the other members of the fauna occur. This species is said to occur in the Carboniferous Slate of Clonakilty, co. Cork (Bailey), and in Carboniferous Limestone near Harrogate and Bolland (Phillips); but there is the gravest doubt in my mind as to the correctness of this specific determination, for according to my own observations this species is never found in the Carboniferous Limestone, but is characteristic of the Lower Coal-measures and Millstone grits and the shales below them.

I have shown (Pal. Soc., vol. xlix, Monograph on *Carbonicola*, *Anthracomya*, and *Naiadites*, pp. 82–145) that the genera *Carbonicola* and *Naiadites* both occur low down in the Calciferous Sandstone Series of Fifeshire, but that the species are different to those occurring in the Coal-measures; and I have pointed out that, similar conditions of deposit being suitable, the same genus returned at several horizons. In the slates of South Yorkshire not only do the same genera occur as obtain in the Coal-measures, but a very large number of the same species are common to the two horizons. These shells must have survived in some outside area, during the deposition of the intervening beds in which they are absent, to return when conditions became again suitable for their migration and survival. This theory demands, not that the beds of one deposit are continuous with other beds at two and more widely separated horizons, but that both beds, containing a practically identical fauna, were the result of one successively continuous series of events. This argument, of course, applies equally well to those beds which have the typical Carboniferous Limestone fauna.

Now, if carried to its ultimate conclusion, the fact of the presence of these beds containing a Carboniferous Limestone fauna at various horizons in the Black Shales (Congleton Edge), the Millstone Grit (Sawley, near Ripon), the Lower Coal-measures (the roof of the Bullion Coal), and in the Coal-measures themselves (the Penneystone of Coalbrookdale, the roofs of the Gin Mine and Bay Coal, North Staffordshire), emphatically proves Sir Andrew Ramsay's contention that the Carboniferous system was one great succession without a break; because the fauna characteristic of its lowest beds survived during the whole of its duration, a few species probably being preserved into Permian times. But, notwithstanding this unity, there is a well-marked line along which a division can be made into Upper and Lower Carboniferous, for which there are strong grounds, both lithological and palæontological, that is, where limestones of typical marine character ceased to be deposited, and shales and grits with coals took their place, denoting a shallower water and more frequent return to terrestrial conditions, and containing a fauna for which these conditions were suitable.

I have shown in the introduction to my Monograph on the British Carboniferous Lamellibranchiata (Pal. Soc., vol. L, 1895, pp. 10–15) that the Carboniferous series as developed in Great Britain and also in Europe and North America, lend themselves best to a twofold classification, which I have summarized as UPPER CARBONIFEROUS or Anthraciferous, and LOWER CARBONIFEROUS or Calcareous series; and I need not enter further into detail here.

This base line of the upper division would, in Derbyshire, North Staffordshire, and Yorkshire, be at the top of the uppermost thin limestone; for in a few localities the massif of Carboniferous Limestone was succeeded by a short series of passage beds, containing thin limestones with a Carboniferous Limestone fauna, e.g. Butterton Moor, near Leek (Proc. Geol. Assoc., vol. xi, pp. cxxxi, cxxxii); and in the Wensleydale district and Northumberland the topmost bed of limestone would also form the limit, and this line of division is really a palæontological one, and not lithological, because it is at this horizon that the characteristic fauna of the Carboniferous Limestone series ceases to be persistent. The beds above the limestones would then be Upper Carboniferous, and would include the shales below the grits, the grits, and Coal-measures, characterized by faunas No. 1 and No. 2.

There is a great similarity between the deposits of this series, there being several workable coal-seams in the grit series, and many beds of coarse sandstone in the Coal-measures; and in addition, the whole of this series is characterized by an absence, with rare exceptions, of marine conditions. There occur frequent interruptions in deposit due to terrestrial conditions, and, moreover, the palæontology of this series is as a whole very different from that which obtains in the beds below, and is peculiarly characteristic of it.

Some objection may be taken to this division from the fact that several beds of limestone occur at various horizons in the Coal-measures. But these beds have, as far as is at present known—and I have examined several, and many have been reported upon by officers of the Geological Survey and others— a totally distinct fauna to that which is entombed in the lower limestones; the one difficulty in the Midland area being whether to place the Pendleside limestones in the lower or the upper division. My own view is, that the fossils agree more with the fauna typical of the Carboniferous Limestone than with those above.

Again, it may be asked, why, with three distinct faunas, make a twofold division? and the answer is that, although it would be impossible to draw any line of demarcation between the beds containing faunas No. 2 and 1, which are so much intercalated, the fauna of the lower series is so characteristically different; or, with greater reason, it may be asked why even a twofold division? The reasons for this are, first, that a review of the Carboniferous rocks of the world seems to demand such; and, moreover, the fauna of the limestones, although it did occasionally reappear for a brief period in the upper beds, is so typical of the lower beds; and I claim that the binary division of Carboniferous rocks is therefore based solely on palæontological grounds. Mr. R. Kidston considers that the plants distributed through the Carboniferous rocks "clearly indicate a great twofold division," and in the main his division is identical with mine, although he does not appear to recognize that the Yoredale Series of Wensleydale is only the equivalent of the upper part of the Carboniferous Limestone; but as he says that he has seen no plants from that series, and had no personal knowledge of that district, he has not based any evidence for his classification on those beds.

Geological science knows no hard and fast lines, and classification, though founded on natural laws, is not a law of nature, but purely utilitarian in purpose; but to be of any service at all, even the classification and division of series of strata must be based on the soundest palæontological evidence.

The recognition of the true place of the series of rocks in Wensleydale, although, of necessity, abolishing the term Yoredale Series as one of the primary divisions of Carboniferous rocks, does not render it obligatory for that term to altogether sink into disuse. The name may very well be used to denote the change of character in the series, due to causes which acted locally, and to represent the Carboniferous Series as it occurs in Wensleydale, Swaledale, Teesdale, and the upper parts of Wharfedale and Ribbledale. But the use of the term must be restricted to this district, and beds of an altogether higher series, with a totally different fauna, must be no longer confounded with them because they appear to occupy a position between two arbitrary and discontinuous base-lines. Currents, reefs, and the differences in depth of a shelving shore, will account for any of the difficulties of tracing any one bed for a distance; and it must be remembered that much of the deposits must have been extremely local, and that many strictly synchronous deposits must have differed entirely in their composition and mode of deposition, and that denudation will not account for all the apparent breaks which are discovered on attempting to map a district.

Note.—Mr. Morton writes that in the North Wales series, mentioned on p. 165, "the Arenaceous Limestone and Upper Black Limestone are one and the same subdivision."—W. H., April 15, 1897.

V.—Water *versus* Ice as an Explanation of the Surface Beds of Eastern England.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

IN former papers on the surface deposits of Eastern England. I have analyzed the conditions of their occurrence and the character of their contents in view of the current theory which makes them the products of ice during an Ice Age. I have endeavoured to show that, tested by every empirical method, they utterly fail to sustain such a conclusion;—that in every character by which we can test these beds, or their component parts, they clearly and emphatically point to some other origin and cause than that of ice; and, on the other hand, that ice such as it is known to us, either in our laboratories or in Nature's laboratory, is quite incapable of producing the results demanded from it by the champions of the Glacial School who have discussed the surface geology of Eastern England. This negative conclusion is, of course, a very important one when we consider what a dominating influence this School has at this moment, not only among official geologists, but among the pundits of Burlington House, where Lyell's followers have pushed their master's teaching to the most extravagant and outrageous length.

If ice be an impossible cause of the phenomena we wish to explain, and if the teaching of half a century on this question will certainly in great part have to be reversed, whither are we to turn, except to the cause which satisfied the *Patres Conscripti* of our science in the days when, before a man became a geologist, he thought it necessary to have a wide and generous training in other sciences and branches of knowledge, men who were mathematicians and physicists as well as geologists, who were in the habit of verifying the capacity of the causes to which they appealed, and who were not tied to some preposterous scholastic prejudice like the theory of Uniformity. They appealed without doubt or difficulty to Water and not to Ice as the main and the efficient explanation of the phenomena of recent geology. At their feet I learned what I know, and by their creed on this question facts and logic both compel me to abide. Water has this supreme claim over Ice, that, whereas the phenomena to be explained absolutely refuse to conform to the proved qualities of ice, they are all consistent with the qualities and characteristics of water. There is not one of them which is not so. Water can carry as heavy weights as ice, and can carry them as far.

Water loaded with stones can score and tear the surface of a country and can make striæ on boulders. Water in great volume, and moving headlong, can sweep with it great banks of clay and loam, and throw them down in heterogeneous disorder. These are the principal earmarks of phenomena supposed to be especially glacial. On the other hand, water, and water alone, so far as we know, can roll angular stones into subangular and rounded boulders. Water alone can sift out and separate clays and gravels and sands according to their several specific gravities. Water alone can traverse a country and pick up as it passes along the débris it meets on the way and mix it together, and then, when arrested, or from some other cause, break sporadically in various directions, carrying its load hither and thither. Water coming from different directions can bring the tribute of different districts into the same cauldron. Water in great masses and moving rapidly can traverse a country irrespective of its surface formation, and mantle it over with continuous beds of softly outlined contour, leaving a great load under the lea of some obstruction, and sweeping clean the places where its current forms a "race." Water drops its load according to its specific gravity, the heavy burden generally first and the light one later. Water can mix tender shells with other and harder materials and carry both together, and lay them down together. Water can take up great masses of soft materials and redeposit them without breaking their continuity. It is continually removing masses of turf and bog in this way. Water alone can, so far as we know, arrange beds and sands in long continuous fine laminæ, marked by every variety of gentle curve. Water alone can take up masses of clay and lay them down on stratified sands without breaking up their layers of stratification. Every difficulty which we have criticized as inconsistent with the handiwork of ice disappears if we admit water as the alternative postulate. This was seen and conceded by the great masters of old days, Sedgwick and Conybeare, Hopkins and Murchison. It is said in light and airy fashion that these men had not our materials to work upon, nor our powers of generalization. I wonder in what single respect these old men fell behind when facing great dynamic problems like the one we are discussing. What men now living can claim the tremendous experience, grasp and knowledge, the clear vision and unflinching logic, of some of the greatest of these old heroes?

But we are told they lived before the sun of geology had really risen. These old men, it is true, had not realized that modern geology would become a deductive and not an inductive inquiry, like every other science, nor could they know that its real corner-stone was not to be finally laid until Ramsay formulated, from the Chair of the Geological Section of the British Association, that splendid product of modern scientific logic, namely, the dictum that Nature had never, either in kind or degree, exceeded her present methods or employed greater and more far-reaching powers. This is the shorter Catechism of the New Faith, which is to dissipate that of the older Prophets. Francis Baron Lord Verulam, let me take off my cap to thee! What dost thou think of at least one science as it is taught in the end of the nineteenth century? I am not alone in my protest. What a remarkable thing it is to read in the pages of so ardent a Glacialist as Mr. Carvill Lewis, for instance, when, having told us the great Chalky Boulder-clay occurs only in non-glaciated areas (p. 216), he despairingly asks if it be not due to torrents of water rushing westwards and bearing cakes of ice? (p. 233, note).

That water could do what is needed, I know no one who disputes. That it could do what ice could not do, some of us think we have shown; but the necessary conditions are, that it must not be water acting in a normal way, but in very large quantities and moving very boisterously, and this is the crux that is so hard to face by the patrons of scholastic science, and hence why those who claim to explain phenomena by adequate and not inadequate causes are not answered seriously, but are remitted to ridiculous references to Noah and his Ark, and treated to other absurdities of a despairing logic. Even the good souls who feel that to water we must eventually turn for the greater part of our explanation are constrained to put themselves in a straight jacket and to try to make a pail of water do that which requires a reservoir, and this entirely because Lyell or Ramsay or some Pope has issued an encyclical *De Uniformitate.*

Thus one school of geologists invokes a general and long-continued submergence, during which fleets of icebergs were floating about the whole land, and travelling between Shakespeare's birthplace and Tennyson's, and between the land of Burns and that of Cowper. Such a submergence, proceeding gently and lasting long, is supposed to in some way square better with the tender feelings of Uniformitarians; and as one submergence is not enough and fails to account for the phenomena, others postulate, with the greatest *sang froid*, several elevations and sinkings to the extent of 1,000 feet or more, as if they were the most ordinary occurrences in Nature, and as if these good Uniformitarians were not living on an island which, so far as we can judge by the evidence, has not moved either up or down for at least 2,000 years. So long as the movement is exceedingly slow, so long as there is nothing spasmodic or cataclysmic in it, it is thought to be consistent with the eternal laws of Nature, however wild and extravagant is the postulate. Hence the readiness with which the theory of submergence, qualified by icebergs as the cause of the surface phenomena of these islands, has found so much favour. Let us analyze it a little. There is no scalpel so effective in dissipating a geological tumour as a little analytical sifting of details.

In the first place, if we are to account for the Chalky Clay by a submergence, we must carry the submergence as far west at least as Warwickshire, and we must put the whole country under water from the Tees to the Thames.

If the phenomena of the distribution of the boulders are to be explained by the portage by icebergs, then it also follows that Mount Sorrel and the other high ground in Leicestershire, as well as the Chalk Downs of East Anglia and Lincolnshire, must have been completely submerged. If so, how is it possible for the icebergs to have got their loads of native stones at all, for the whole country available for stones would be submerged, and floating bergs cannot collect stones from the sea-bottoms over which they are floating. Nor could such bergs get the stones on their backs, for icebergs are merely the terminal feet of glaciers which have calved off, and, as we have shown, there were no glaciers in Charnwood Forest and there are no remains of ice-action there. So much for the local boulders: now for the strangers. How were icebergs to collect their load of stones in Cleveland and Lower Durham, when Eastern England was submerged at least a thousand feet? But these stones, like those from the Christiania Fjord, are mostly rounded boulders or subangular blocks. They must have been rolled and worn by some force before they were picked up and scattered. How could icebergs collect them?

Having collected them, how could they proceed to scatter them over the wide area of the Chalky Clay and its associated beds, and leave them not in heaps, but sporadically; and how could these icebergs come down upon Eastern England from almost every point of the compass? On the banks of Newfoundland, in Baffins Bay, in the South Pacific, wherever, in fact, we have streams and fleets of icebergs depositing loads of stones, they all have a uniform route. Nor can we see why, if the march of the old icebergs were divergent, the boulders from Norway should occur nowhere on the British coasts except between Robin Hood's Bay and Cromer.

Nor, again, can we see how by any possible means icebergs could either get hold of or move about or transplant the enormous cakes of chalk, oolite, etc., many hundreds of yards in length, whose portage has been attributed to them, or underlay them with soft drifted sand and clay. If they were foreign bergs floating in, how could they by any means take up and detach these monster boulders. They could not get them on their back, and it is impossible to understand how they could get them attached to their feet. Floating bergs cannot get frozen to anything. What applies to the bergs, applies also to shore-ice. Shore-ice will, no doubt, move stones along shore, and sometimes push masses of stone up sloping beaches, but shore-ice cannot perform the feat of taking up great masses of chalk and depositing them in beds of loamy sand with their laminations intact. Besides, shore-ice implies a shore, and how is it possible to have a shore at Cromer or in Mid-Lincolnshire where the postulate is, that the whole country was submerged a thousand feet deep. Nor are there any traces of old beaches or shores to be found where these great stony masses occur. Floating or shore-ice, therefore, seems out of the question as a cause of the boulder formations of Eastern England. Let us, then, turn to the supposed handiwork of the sea during a prolonged submergence. Does the eastern half of England look in the least like an old sea-bottom. If it were submerged for any considerable time, where are the marine débris, the shells, etc. There is literally not a single specimen known to me, for, as we have seen, the shells once supposed to be glacial shells in certain local maritime districts are all derivative and belong to the horizon of the Norwich Crag. The question has been asked over and over again, and bears repeating. It is literally incredible that such a wide district should have been submerged without leaving a trace of shells or other marine débris to attest it; but this is not all. If the submergence were gradual and the upheaval the same, we ought to have endless traces of beaches and shore-lines. Where are they? Again, how could the sea mix the contents of the Chalky Clay, and distribute them as we find them over hundreds of square miles of country? Nothing is plainer than that the active operations of the sea are carried on within a very short distance of the shore. It is only there that wind and current chiefly work, and that gales and storms are effective. In deep water and away from the shore, the bottom is quiescent, and we have virtually no dynamical action. How, then, are we to understand the bringing together and mixing of the rocky débris of the surface beds and their distribution, as we find them, by means of ocean-waters, the deposition of the clays and the sands and gravels in the extraordinary way we find them, the occurrence of the Chalky Clay only on one side of the chalky downs, the general drift of the materials in one direction from their old source, and the sporadic scattering of the mixture in all directions? There is literally not one single feature in these beds which seems to me to be consistent with their having been the product of a long-continued marine submergence assisted by icebergs; and I cannot help suggesting that those geologists who are too experienced in the ways of land-ice and know its capacity too well to believe in the fantastic nonsense that has been written about ice-sheets, have in their despair appealed to an alternative so lacking in empirical support, because they must seize at any straw rather than surrender their fetish of Uniformity.

Another theory to account for the Chalky Clay and its associated deposits was formulated by Carvill Lewis, and it retains a considerable importance since it has received the countenance of at least one prominent English geologist. Lewis formulates his view thus:—(1) "The Hessle Clay is due to a marginal lake. (2) When this marginal lake burst westwards through various channels in the chalk wolds it made an angular, torrential, flinty gravel; the unfossiliferous 'boulder-gravel' or 'cannon-shot' gravel of Cromer and Norwich. (3) Debacles thus flowing into the lower ground on and west of the Chalk wolds, formed a more inland and second series of lakes, which contained a mud filled with chalk; and this is the great Chalky Boulder-clay. (4) This lake in turn filled up and overflowed west and south, past Leicester and Rugby, etc., along the Triassic country, making flinty and chalky gravels, the Northern Drift of the Midland and Southern Counties, which is torrential. (5) Rivers from glaciers at York and in Cheshire joined the flinty streams." ("Glacial Geology of Great Britain," p. 334, note.)

When we read a series of *obiter dicta* like these, stated with the utmost *sang froid*, without the slightest evidence of any kind to support them, and are told this is science, it makes us feel almost uncomfortable. So far as I know, there is not a single feature of any kind presented by the surface beds of Eastern England which in any way resembles a lake deposit. Nor can I see how any lake could possibly exist in this part of England, on the scale and of the character required to explain the phenomena. If we make a contour map of the area occupied by the Chalky Clay and its associated deposits, and try to realize how by any process the district they occupy could be converted into a lake, we shall indeed be puzzled. Lakes cannot exist without dams or fences to restrain and keep back their watery contents. What and where were the dams in this case? We have shown the impossibility of conceding a solid North Sea to act as a barrier on the east; but even if we could concede it, how is it possible to believe that a lake of open water could exist on the west side of the great icy barrier, when the climatic conditions in the North Sea were such as to be consistent with a solid ice-mass there? But granting such a barrier on the east, what were or could be the barriers of such a lake on the south and west? These barriers must have been stupendous, if we are to account for the Chalky Clay and its associated beds at the various elevations at which they occur. Where is there a trace of anything of the kind? Where, again, are the fresh-water shells, which would certainly be found in large sheets of fresh water, such as this is supposed to have been? Where, in fact, is there any débris of any kind pointing to a fresh-water origin?

What, again, of the contents of the beds themselves? Marly clays, no doubt, are deposited in lakes, the result of deposition from the streams that flow into them, but such clays are arranged in regularly disposed laminæ, and are not heterogeneous masses such as the Chalky Clay is.

Again, this Chalky Clay and the associated gravels and sands could not have originated in the bottom of the lake itself, from the disintegration of its own bed. Lakes do not deepen themselves by a process of disintegration of this kind; they are gradually and continuously being filled up by accumulations. So that these soft beds must have been brought in by streams, but if so, how is it they are not more efficiently sorted? It is true the sands and gravels are separated from the clays, but each of these sets of beds is studded with blocks and boulders, which have only in rare cases come from a distance, and for the most part are derived from the locality, and which under the influence of gravity would have been sorted apart if their portage had been like that of other river-borne materials.

Again, when rivers bear materials into lakes they do not drop them all over the lake-bottom in the irregular fashion we see in these beds. They drop them in a most methodical way by making deltas, which gradually enlarge until they fill up the lake. There are no deltas here, nor anything like deltas.

Where, lastly, are we to get the rivers in the particular area in question whose current and force should be equal to carrying the stones and shingle and gravel, which form such a large proportion of these beds? They must have been torrential rivers with rapid falls to have done so, but there is no fall, or virtually none, in the rivers of Eastern England; and how could rivers by any process convey into a lake deposits which are distributed, as these surface beds are distributed, over an undulating surface? Rivers cannot run up and down hill, and how could the contents of these beds become mixed in the particular way we find them mixed in a lake? How could rocks from Norway and rocks from Durham be mixed with those from Mount Sorrel and from the wolds of Lincoln and Norfolk? A lake is not a churn, in which the contents are being tossed about and mixed by some uneasy force. A lake is a singularly quiet bourne, in which those objects which are conveyed lie at rest; and the work required in the present case, as we have seen, is the bringing together from the four quarters of heaven of stones and other ballast, mixing them and then distributing them. If this were done by rivers, the rivers must have had the art and capacity of flowing in opposite directions, a postulate which would have staggered even Dr. Croll. The fact is, one can hardly restrain one's patience in having to dissect and show the futility of a theory so void of every rational element as that which attributes the soft deposits of Eastern England to the operations of a lake. It is little short of scientifically criminal for a man with high abilities who has acquired a certain reputation to bewilder and defy the world by throwing down such crudities, as if they settled anything or answered any real questions, and to offer a factitious shield behind which a crowd of thoughtless people, whose science is all deductive, and who never sing solos but only join in a chorus, may take their stand.

The lacustrine theory exhausts the various explanations of the soft beds of Eastern England which involve water operating in its normal methods. If, as I have argued, water is not only capable of explaining the phenomena, but is also alone capable of doing so, it must, therefore, be water acting in quite a different way to its normal methods. It must have been water acting in great masses torrentially, such as was invoked by the Old Masters of Geology, acting in the way, in fact, in which I have invoked it in my "Glacial Nightmare." To this explanation I have seen no reply except a pious exclamation of horror or two at such a daring departure from the pontifical authority of Sir Charles Lyell. This expression of opinion does not affect those who have never worshipped at that shrine, and who believe with Sedgwick and Murchison that the forces which *periodically and continuously* have torn and contorted the crystalline rocks of the Alps, which have tossed the Miocene beds of the Rigi and set them on their edges, and which have done stupendous work of a similar kind in all latitudes and in all geological ages, were not exhausted when we come to the end of the Tertiary period, and were as capable then as they had often been before of crumpling and bending and breaking the earth's crust, in Titanic fashion, and will assuredly repeat their rough work again presently. This now is the real inductive theory of Uniformity, to which the bastard theory of

Uniformity, which claims the manifold rents and twists and contortions of thick beds of hard crystalline rocks, faulted and fissured and fractured as they so often are, as the effects of the repetition of raindrops and the diurnal erosion of river and tide, has no claim.

Those who would concede this, either wholly or in part, as a general conclusion, nevertheless bid me produce direct evidence that such throes and dislocations took place in a period so recent as the Pleistocene. This is not unreasonable, although the men who champion the cause of ice absolutely refuse to explain the competency of ice to do the particular work they attribute to it.

I am now, of course, limiting myself entirely to the problem presented by the surface beds of Eastern England. That problem, as it presents itself elsewhere, I hope on another occasion to face. Now in regard to the area at present under discussion, I have already shown in these pages, by a very considerable accumulation of evidence, that during the Pleistocene period a vast and extraordinary folding, twisting, and breakage of the strata did occur which operated over all the district, so far as we know, occupied by Secondary and Tertiary beds, from the great Chalk escarpment in the west, as far as Denmark and Scania in the east; and this view is supported not only by a heretic like myself, but by highly respected foreign geologists like Koeppen and others. If this be maintainable, then I have surely met the challenge of those who ask for proofs of great dislocations in this area in Pleistocene times. If it be not maintainable, then I should be very grateful indeed to anyone who will answer the arguments I have used, and which have been used by better men than myself, and refute the points I have quoted.

This particular dislocation seems, in the main, in this area to have involved some lateral compression or some east-and-west tellurial wave, by which the beds were thrown into folds ranging north and south, raising a series of round-backed wolds, and causing a corresponding series of deep depressed valleys between them. The extent of these depressions can be measured partly by the depth at which the land is now submerged below the sea-level between England and Denmark, over an area on which the Mammoth and its companions roamed; and, secondly, by the well borings at Yarmouth, Boston, etc., in Eastern England, and by others in Holland, which prove to what a depth below the sea-level the former land surface was lowered at this time. The depression was filled up by drift-beds, all dating from our period. The evidence of these wells seems to me to be crucial and critical.

I have also shown in the same paper that the movement here referred to was not a gradual and continuous movement. I am not a great believer in general movements of the earth's crust over large areas which are gradual and continuous. The earth's crust is not like dough, under the influence of yeast. Its movements, when we can follow them, are generally spasmodic and rapid, and involve breakage and tearing, and the evidence in this case, as I have tried to show, is consistent only with this conclusion, a view also held by Murchison.

What, then, have we to face? Why, the fact that at the very time when these soft surface beds of Eastern England, which have set the chorus of glacial geologists singing their monotonous melody, were distributed, there was a widespread and tremendous dislocation of the solid crust of the earth over many degrees of longitude, inclusive of the area where these beds occur; a dislocation which was very rapid, if not sudden and cataclysmic. About this I have no doubt whatever. The conclusion seems to me absolutely unanswerable if we are to accept induction as our teacher.

If this be so it is equally certain that such a dislocation, involving a tremendous downthrow of the strata far below the ocean-level over the area now occupied by the southern part of the German Ocean, must inevitably have been accompanied by a tremendous inrush of water on a vast scale from the areas in the north and north-east, where open water then existed from the seas of Scotland and Northumbria, and from the Baltic and its gulfs, thus supplying the very machinery which that famous and most accomplished geologist, Hopkins, a great physicist and mathematician, invoked hypothetically; a postulate which was supported by Whewell, another of the really great men of genius of this century, and accepted by Murchison. "*Fides magister meus.*"

Thus do we answer those who demand whence we would derive those vast waves of translation, whose competency the champions of the current school have not the temerity to question. Waves which would under the circumstances and conditions named literally treat the foreign stones, whose portage causes so much trouble to the glacialist, as a child treats its marbles, would overwhelm the land, irrespective of its contour, as such waves on a smaller scale have done in Japan, mixing the freight they brought from afar with the loamy débris they met with *en route*. These waves take up with their powerful and yet at times gentle hands, as we have seen done in smaller areas, vast masses of solid rock or even of soft débris, and move them from lower to higher levels, padding them round with current bedded sands and concentric laminæ; taking up, as has been done elsewhere, great masses of heterogeneous clays or rough gravels, and throwing them down in heaps when the contour of the country arrested their force, and in other cases, where the waters were not so turbulent, passing over laminated beds with little disturbance, and overlaying them with sands and clays with curved laminæ and layers, as may be seen *in petto* after great storms; in some cases hardly disturbing the sands and gravels already on the ground, in others tossing them about and mixing them with foreign stones, when rushing into a great hollow like the Fens, mixing as in a cauldron the various ingredients they met with, clay and stones of different kinds, and then, as they spread out and spent themselves on the heights above the Thames and the uplands of Warwickshire, spreading a more or less continuous mantle of homogeneous structure, geographically distinguished by the preponderance of local débris. They would end not as ice-deposited débris could have ended, by a great series of concentric ramparts and moraines, but by the deposit gradually thinning out. As they swept along in places, rough rubble, made of chalky and oolitic fragments, scoring them occasionally, and generally polishing them by rubbing them together as we notice the tide rubs the shingle together when it grates upon our ears, when one great loaded wave after another retires down a shelving slope, and it would not, like ice, carry big stones and little together, but sort them as we find them sorted, the biggest specimens being, in the main, nearest to the parent beds.

As we have seen, the materials were not ready made; the dislocation of the strata provided the local angular rubble; the pebbles, shingles, and sands were already there in the shingle beds and sands of Tertiary age, while the clays were also bare and ready to be churned. It needed only a powerful instrument, powerful and yet light-fingered. Such an instrument is the one I have here quoted, not for the first time. I know of no other capable of doing the work, and for the existence and potency of which there is such a preponderance of evidence, and in the effective phrase of Euclid I would say, until some champion can furnish a better cause, Q.E.D.

I have limited myself in this paper entirely to the deposits of South-Eastern England and the maritime borders of the North Sea on both sides of the water. It is necessary to point out to some English geologists that the phenomenon to be explained is not a parochial one and limited to these islands. The same kind of stones which have come to Britain from the Christiania Fjord have also been found in Holland. The same disturbance and rearrangement of the Crag sands which have caused so much false reasoning in East Anglia have occurred, but on a vastly greater scale, in Holland, where these sands are not only found in greater depths but in the form of the so-called Campinian Sands, distributed over a much wider area, and which no stretch of the imagination could suppose were ice deposits nor the deposits of subglacial streams, since they uniformly mantle whole provinces with more or less homogeneous sands, and gradually thin out. I hope to have more to say to them on another occasion.

At present I would content myself with saying that I hold this inrush of water from the north and north-east to have been the real dynamical cause of the effects which have been so persistently attributed to ice. When this inrush reached the loose sands of the Crag it rearranged them; when it reached the Lincolnshire and Norfolk wolds it passed over them or through their gaps, and took with it the chalky débris which it met on their exposed sides, leaving none on their eastern flanks because there was no débris available there. Thus it laid down chalkless clays and loams on one side of the wolds and chalky ones on the other. The same cause would explain the peculiar distribution of the Mount Sorrel boulders.

The North Sea inrush did not do all the work. It could not and did not bring the limestone and millstone grits of Derbyshire into Eastern England, nor scatter boulders from Shap over the Yorkshire plain, nor the quartzite pebbles of Warwickshire over a large part of the South-Eastern Counties. These were the effects of separate impulses, which I shall not shrink from discussing on another occasion, but which I do not wish to confuse the present issue with. In one respect only must I say something of them. There is no more treacherous phenomenon in the world for the young geologists than the various mounds, ramparts, etc., of soft materials which occur in certain districts, and which simulate in a measure the external contours of glacial moraines, just as chalk and water so often in London simulate milk. These are generally seized upon greedily as most patent evidences of glacial action, and are at once labelled moraines, and pass as such into the ephemeral textbooks of our science. It is forgotten that by far the greatest number of mounds and ridges now being formed are being formed by the sea or by torrential waters, and wherever two opposing rushes take place it is inevitable that mounds and banks should occur, and the contours of these mounds will depend largely on the rapidity with which they are formed. Now we have in Eastern England examples of such mounds which have been called moraines on the slightest possible grounds, and which I believe to have been the result of the North Sea rush meeting with an impulse from the west or with some obstacle.

Such mounds and ridges occur in one or two isolated places in Eastern England, notably in Hunstanton Park in Norfolk, in Lincolnshire, and in Holderness. They have been treated as glacial moraines; I do not know on what grounds, unless it be on the easy ground that every mound, however formed and whatever it contains, must be a moraine. These particular mounds bear no relation known to me to any possible glaciers, but do bear a very near relation to the mounds and ramps formed by rapid currents converging from different directions upon the same spot.

In regard to the mounds at Hunstanton Mr. Carvill Lewis, a very strong glacialist champion, says :—" I visited the so-called esker in the Park near Hunstanton. I saw in an open field a long hill of gravel resembling a kame in its narrow ridge-like form, but not resembling one in that the characteristic knobs and kettle-holes were absent. . . . . It turned at right angles, and continued as a narrow gravelly ridge in an E. and W. direction for one-third of a mile . . . . it consists, at least in its upper part, of water-worn coarse gravel and sand. This last looked like sea sand, not kame sand. Contortions with a little clay in them were seen in some parts of the cutting. I have never seen such contortions in kames, although they are common in marine drifts. Finally, in the sand I found many fragments of marine shells. Shells never occur in kames, and he concludes that the mound is not a kame but a portion of an old sea-beach. It is close to the sea, only 50 feet above it, and bends in an arch quite unlike a kame, but just as a beach might, keeping parallel to the present sea-beach. One part is parallel to the Wash, another part to the sea, and it stands just on the point between the two. *Possibly it was caused by the two currents, one of the Wash, the other of the open sea.* It is clearly marine, like the gravels of the neighbourhood. Is it a dune? or a bar? or a bank?" ("Glacial Geology of Great Britain," pp. 340-1.)

The same writer refers to a curious ridge of Boulder-clay extending from Slickney through Sibsey in Lincolnshire, and significantly adds: "This is a shoal or bar" (id., p. 333). Again, he says:—"Above Louth is a very low flat ridge of local character parallel to the chalk cliff, but a quarter of a mile east of it, made of Hessle Clay. *It has none of the characters of a moraine, but has the shape of a subaqueous sand bar or mud tank*" (id., p. 235). I hold that the same arguments apply to the mounds and ramparts of Eastern Yorkshire which have been so readily accepted as moraines by writers who see ice everywhere, and I prefer to strengthen my view by a quotation or two from the writer last named, who is so often frank where frankness is much needed. He is disposed to treat some of the mounds as morainic, but has to confess that those near Gristhorpe are rounded in outline as if either made in water or subsequently submerged (id., p. 206). In regard to the hummocks between Breckton and Speeton, he associates them with the similar ones in Holderness which contain shells and shell fragments, showing, as he says, "that if it is a moraine it was made under water," while the fauna is much less Arctic in character than in the Bridlington Crag beds. Where shells do not occur the beds in these mounds are sorted into sands and clays and gravels, and rudely stratified conditions quite inconsistent with true moraines, which consist of heterogeneous "muck."

The laminated clays and the sifted sands in these mounds are assuredly conclusive evidence that they were made by water and nothing else. The fact is, glacialist champions are content merely to note the existence of mounds somewhat resembling in their outward contours those left by glaciers, and forget that water deposits similar mounds; and in order to test whether they are moraines or not we must make sections in them and see whether traces of stratification and sifting are to be found. In regard to the mounds and so-called eskers of Eastern England, those I have seen bear the inevitable impress of having resulted from contending currents of water, sometimes rushing at a rapid pace and sometimes retreating, and are in no sense moraines at all. The best proof that they are not moraines is to be derived probably from the corresponding Flemish deposits. There we should expect to see these mounds repeated on a great scale if they were moraines, for the country is flat and uniform in outline, but instead of this we have a uniform mantle of gradually thinning-out sands. This thinning out, again, is quite contrary to all the analogies of glacier deposits, which are deepest at the foot of the glacier, and, like the similar thinning out of the Chalky Clay and the gradual diminution of the size of the boulders as we depart from the centre of distribution, is only consistent with a widely extended tumultuous current. Such a current, or rather a series of currents, has, in fact, been postulated by the extreme glacialists to account for the distribution of the English so-called glacial gravels; or, rather, by those glacialists who realize that gravels can only be moved by torrential waters, and that rivers do not run up and down hills and lay down gravel on the hill-tops as well as the valley-bottoms. Thus, Lewis attributes the distribution of the so-called cannon-shot gravel to the action of a powerful current, and he quotes the apposite fact in proof of it that the stones frequently have their longer axes vertical and the flints are often quite unworn; and he accounts for the flinty gravels of the Midlands by the bursting of a series of lakes, thus causing a number of debacles (op. cit., p. 234).

How ready these champions of Uniformity are to go to Saturn for their unproved, untested, and absolutely hypothetical machinery! Another feature of the drift-beds has also, in my humble view, been distorted to prove a quite preposterous position by the orthodox geologists. Because valleys very often have their flanks fringed by so-called glacial beds, it has been argued that they were once entirely filled up with this material, and that all of it has been removed by subsequent denudation, leaving only these marginal beds. How this denudation was brought about in a district where no denudation whatever, or virtually none, now takes place, where every stream is raising its own bed, and where the materials of this portentous denudation were carried to, we are not told. The fact is, that the phenomena in question are the most patent evidence of a great rush of waters which scoured the valley bottoms, but left a marginal terrace or series of terraces of débris just as every flood does, and swept along the greater part of its load, choked and jammed the greater part of it in the upper reaches of the valleys. The theory that these valleys have been cut down or carved out of the so-called glacial beds is absolutely at issue with every serious fact except the most superficial one, and has entirely reversed the course of geological reasoning on the subject.

From every point of view, therefore, I claim to have shown that the old geologists are right and that the new ones are wrong on this issue, and that it was water and not ice which laid down the surface beds and gave a final contour to the surface of Eastern England and of Holland.

In disputing, as I have so persistently done, the extravagant claims of the glacialists, I have really done so in the interests of a rational uniformity. I do not doubt that in former days the mountains of Scotland, Cumberland, and Wales may have nursed glaciers, and that these glaciers could do and did similar work to modern glaciers. What I deny is the potency of those glaciers to distribute the result of their handiwork over the flat lands of Eastern England. I also deny the capacity of ice to travel over hundreds of miles of level or undulating country from Scandinavia to the Carpathians and to Norfolk, and to perform work contrary to the proved capacity and nature of ice. I affirm that the geological facts refuse to be correlated with such a hypothesis, but everywhere speak of a great diluvial movement.

VI.—On the Microscopic Contents of a Sample of Bracklesham Clay from Lee-on-Solent, Hampshire.

By Frederick Chapman, A.L.S., F.R.M.S.

IN 1862, Professor T. Rupert Jones published some notes on a careful microscopical examination of five samples of clay from the Bracklesham beds of Bracklesham, Selsea, and the Isle of Wight (?).[1] This paper gave a good idea of the systematic methods which could be employed in working over a sample of fossiliferous material, especially when rich in microzoa, and the results of which are often of great use to geologists and palæontologists.

Upon the lines there laid down, the following study of a sample of clay from Lee-on-Solent has been made at the request of Professor Rupert Jones; and he has further kindly suggested that, since the microzoa have had much attention directed towards them of late years, these notes are worth publication, for further reference in connection with beds of the same age from other localities.

The bed from which the sample of clay was collected[2] lies about 250 yards west of Lee Pier.[3] It crops up out on the beach-level. The cliff at this spot is capped with drift, composed of flint, chert, and quartz. Beneath this is a bed of sand, and this is immediately underlain by the fossiliferous Bracklesham bed; but of this there is very little exposure.

Results of the Examination of a piece of Bracklesham Clay, weighing 480 grains.

A dark-green sandy (glauconitic) clay.

	Argillaceous.	Arenaceous.	Calcareous.
Total of 480 grains, separated as follows	280 grains	135 grains	65 grains
Approximate percentage of constituents	58·3	28·1	13·54

Mineral Constituents observed in the fine sandy residue after washing.—Quartz, Tourmaline, Zircon, Rutile, Glauconite.

Organic Remains.

Pisces. *Lamna* (?), fragment of tooth.

Gasteropoda. *Solarium canaliculatum*, Lamarck, one specimen; *Pleurotoma callifera*, Edwards, one specimen.

Lamellibranchiata. *Crassatella Bartonensis*, Edwards, one specimen; *Corbula pisum*, Sowerby, common.

Bryozoa. *Orbitulifera petiolus* (Lonsdale), very common.

Ostracoda. *Bairdia contracta*, Jones, very rare; *Cythere striato-punctata*, Jones, very common; *C. scabropapulosa*, Jones, frequent; *Cytheridea perforata* (Römer), rare; *C. Muelleri* (Münster), very rare; ***Krithe Bartonensis*** (Jones), very rare; ***Cytherella Dixoni***, Jones and Sherborn, very rare; ***C. compressa*** (Münster), rare; ***C. Beyrichi*** (Reuss), rare; ***C. Reussi***, Jones and Sherborn, rare.

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[1] "On the Microscopical Examination of some Bracklesham Beds": The Geologist, February, 1862, pp. 59–63.

[2] I am indebted to the Rev. R. Ashington Bullen, B.A., F.G.S., of Reigate, for the fossiliferous clay from Lee-on-Solent; and he has also kindly furnished me with the notes on the position of the beds in the locality, as given above.

[3] Lee-on-Solent, formerly Stubbington.

COELENTERATA. ***Turbinolia humilis***, Milne Edwards and Haime,[1] two specimens.

FORAMINIFERA. ***Miliolina trigonula*** (Lamarck), very rare; ***M. Schreibersii*** (D'Orbigny), very rare; ***Haplophragmium foliaceum***, Brady, rare; ***Polymorphina gibba***, D'Orbigny, very rare; ***P. lactea***, Walker and Jacob, very rare; ***Nummulites variolaria*** (Lamarck), excessively common.

NOTICES OF MEMOIRS.

I.—MARINE ORGANISMS AND THE CONDITIONS OF THEIR ENVIRONMENT. By Dr. JOHN MURRAY, F.R.S.[2]

THE ocean may be divided into two great biological regions, namely, the superficial region, including the waters between the surface and a depth of about 100 fathoms, and the deep-sea region, extending from the 100 fathoms line down to the greatest depths. The superficial region may be subdivided into two provinces, the shallow-water or neritic province around the land masses where the depth is less than 100 fathoms, and the pelagic province, embracing the superficial waters of the ocean basins outside the 100 fathoms line; these two provinces contrast sharply as regards physical conditions, which are of great variety in the neritic province, and very uniform over wide areas in the pelagic province.

Temperature is a more important factor in determining the distribution of marine organisms, mostly cold-blooded, than in the case of terrestrial species, mostly warm-blooded and air-breathing animals, the distribution of which depends rather upon topographical features than upon climatic conditions.

The pelagic tropical waters of the ocean teem with various forms of life, of which probably 70 to 80 per cent. are plants, converting, under the influence of sunlight, the inorganic constituents of sea-water into organic compounds, thus forming the original source of food of marine animals both at the surface and at the bottom of the sea.

The number of species living in the pelagic waters of the tropics may greatly exceed the number in polar waters, where, on the other hand, there is often a great development of individuals, so that there is probably a greater bulk of organic matter in the cold polar waters than in the warm tropical waters. The rate of animal metabolism is slower at a low than at a high temperature, and organisms inhabiting tropical waters probably pass through their life-history much more rapidly than similar organisms living in polar regions. Carbonate-of-lime-secreting organisms are most abundant in the warm tropical waters, decreasing in numbers towards the polar regions, and it has been shown that the precipitation of carbonate of lime from solution in sea-water takes place much more rapidly at a high temperature. The pelagic larvæ of bottom-living species are always present in the warm surface waters of the tropics, sometimes growing to an enormous size; but they are absent from the cold polar waters and in the deep sea, where the majority of the bottom-living species have a direct development.

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[1] Previously recorded from the Barton beds of Hampshire.

[2] An Address delivered at the Royal Institution.

The Arctic fauna and flora, both at the surface and at the bottom, resemble the Antarctic fauna and flora, and a large number of identical and closely related species are recorded from the two polar areas, though quite unknown in the intervening tropical zone.

The boundary-line between the deep-sea region and the neritic province is marked out by what has been called the "mud-line," where the minute organic and inorganic particles derived from the land and surface waters find a resting-place upon the bottom, or serve as food for enormous numbers of crustacea, which in their turn are the prey of fishes and the higher animals; this mud-line, in fact, appears to be the great feeding-ground in the ocean, and its average depth is about 100 fathoms along the borders of the great ocean basins.

The majority of deep-sea species are mud-eaters; some are of gigantic size; some are armed with peculiar tactile, prehensile, and alluring organs; some are totally blind, whilst others have large eyes and are provided with a kind of dark lantern for the emission of phosphorescent light. The deep-sea fauna does not represent the remnants of very ancient faunas, but has rather been the result of migrations from the region of the mud-line in relatively recent geological times.

The "Challenger" investigations show that species are most abundant in the shallow waters near land, decreasing in numbers with increasing depth, and especially with increasing distance from continental land.[1] This is true as a general rule, especially of tropical waters, but in polar regions there are indications of a more abundant fauna in depths of 50 to 150 fathoms than in shallower water under 50 fathoms.[2]

The various points touched upon regarding the distribution of marine organisms, might be explained on the hypothesis that in early geological times there was a nearly uniform high temperature over the whole surface of the globe, and a nearly uniformly distributed fauna and flora; and that with the gradual cooling at the poles, species with pelagic larvæ were exterminated or forced to migrate towards the tropics, while the great majority of the species which were able to survive in the polar areas were those inhabiting the mud-line. The uniform physical conditions here referred to might be explained by adopting the views of Blandet[1] as to the greater size and nebulous character of the sun in the earlier ages of the earth's history.—*Nature*, March 25, 1897.

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[1] See 'Challenger' Reports, "A Summary of the Scientific Results," by John Murray, pp. 1430-6, 1895.

[2] See Murray, "On the Deep and Shallow-water Marine Fauna of the Kerguelen Region of the Great Southern Ocean": Trans. Roy. Soc. Edin., vol. xxxviii, p. 343, 1896.

II.—The Palæolithic Deposits at Hitchin and their Relation to the Glacial Epoch.[2] By Clement Reid, F.L.S., F.G.S., of the Geological Survey of the United Kingdom.

CERTAIN excavations and borings at Hoxne, undertaken in the year 1896 at the cost of the British Association and of the Royal Society, threw much light on the relation of Palæolithic man to the Glacial Epoch.[3] It was thought advisable therefore to examine the similar deposits at Hitchin, to ascertain to what extent the conclusions already arrived at were supported by exploration at a fresh locality; and the cost of these investigations was defrayed by the Council of the Royal Society.

Palæolithic implements have long been known from Hitchin, and their position in and at the base of a stony brickearth was well ascertained. It was also known that this brickearth rested on loam and shell marl, with fresh-water mollusca and mammalian remains. All this had been made perfectly clear, principally by the researches of Prestwich, Sir John Evans, Mr. W. Ransom, and Mr. William Hill. The most important of the doubtful points were the relations of these ancient alluvia to the widespread sheet of Chalky Boulder-clay and to the valleys of the existing streams.

A preliminary examination of the neighbourhood of Hitchin convinced the author that the Palæolithic and ancient alluvial deposits of Hitchin occupied a small irregular valley, which had become silted up and almost obliterated. Attention was therefore mainly devoted to the search for Boulder-clay beneath the Palæolithic loams, and to the sinking of a trial-pit and bore at the point where the buried valley appeared to be deepest.

This exploration tended to show that the story told by the old valley at Hoxne was repeated at Hitchin. Indeed, the succession of events at the two localities was so similar as to leave scarcely a doubt that there was an equivalent set of strata, although unfortunately the series was less perfect, and the gaps discovered at Hoxne are still unbridged by any records yet found at Hitchin. Hitchin yields strong corroborative evidence in favour of the conclusions arrived at in the Hoxne Report, and adds somewhat to our knowledge of the temperate flora of the ancient alluvial strata lying between the Chalky Boulder-clay and the Palæolithic brickearth.

Hitchin lies in the valley cut by the Hiz, a small stream which rises within a mile of the town. Chalk is seen in the valleys, and rises irregularly through the thick sheet of drift that masks most of the area. The greater part of this drift consists of coarse flint-gravel, partly of Glacial, partly of Palæolithic age; and one of the greatest difficulties met with is the impossibility of deciding whether any particular pit is in Glacial or in Post-Glacial gravel, and whether the gravel passes under or over the Chalky Boulder-clay. The material being used again and again, the composition of the gravel is practically the same in each case, except for the occurrence of implements in the newer one.

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[1] Bull. Soc. géol. France, sér. 2, t. xxv, p. 777, 1868.

[2] Abridged from the Proc. Royal Society, vol. lxi, pp. 40–49, March, 1897.

[3] Rep. Brit. Assoc. 1896, p. 400.

The first thing to be done was to ascertain whether the Chalky Boulder-clay, an undoubted glacial deposit, passes under or over the Palæolithic brickearth. With this object, borings were made in the pits out of which implements have been dug. The author gives details of these borings, the results of which may be shortly summarized thus:—In Ransom's (New) Brickyard, after penetrating the Palæolithic brickearth and underlying fluviatile loam to a depth of 60 feet, some blue chalky clay was penetrated in Bore Hole No. 2, and in BH 1 derivative fossils from the Boulder-clay were obtained at about the same level in the lower part of the old alluvium. In each case boring was stopped by gravelly sand full of water. Other borings in Jeeves' Yard and in some old brick-pits on Maydencroft Farm yielded no trace of Boulder-clay. One only (BH 12) passed through undoubted Boulder-clay. The section is—

			feet.
Palæolithic.	Yellow brickearth and small stones	dug	9
		bored	5½
Ancient alluvium	Yellow and white marl and silt		2
	Yellow loam and small chalk pebbles		½
	Chalky Boulder-clay		9
	Loamy chalky gravel (base of the Boulder-clay)		2
	Gravelly sand (boring stopped by large stones)		8
			36

The site of this boring is close to the western margin of the old channel, Chalk appearing at the surface within a short distance. The occurrence of the Chalky Boulder-clay at this spot at a high level, and its absence, or representation by derivative material, at lower levels in borings made nearer to the centre of the channel, suggest that the channel was, to a large extent, excavated, or re-excavated, after the deposition of the Boulder-clay, as was the case at Hoxne.

The course of the ancient silted-up channel cannot yet be defined. Loam with Palæolithic implements occupies a belt extending for about a mile south of Hitchin.

The underlying river alluvium is entirely overlapped and hidden by the Palæolithic brickearth, and is only to be seen where the brickearth has been dug away. It is found in Ransom's and Jeeves' brickyards, and it has now been discovered half a mile to the SSW., in two borings on Maydencroft Farm. It apparently occupies a narrow belt in the middle of the old valley. The greatest depth of this valley could not be proved, owing to the running sand and gravel, which made boring so difficult. The bottom lies at least as low as the level of the existing valleys of the Hiz and Purwell, for five different borings were abandoned at about that level, without having reached Chalk. The trend of the buried channel seems to be from south to north, in this following the general slope of the ground and running parallel to the course of the existing streams.

The relation of the Boulder-clay to the alluvial deposits having been settled, attention was devoted to an attempt to penetrate to the bottom of the valley in its deepest part. A trial-pit was sunk in Ransom's old brickyard, within a few yards of the spot where a pit had been sunk by Messrs. Prestwich and Evans about 1879. In this brickyard a large number of implements had been obtained from the irregular gravelly base of the brickearth, where it rests on the older alluvial deposits. The newer brickearth, here about 24 feet thick, had been already entirely removed at the spot where the trial-pit was sunk. After sinking 14 feet through brown bedded carbonaceous loam, full of badly preserved shells and plant-remains, boring tools were used, and a further depth of 17½ feet of alluvial loam was penetrated before the gravelly sand below was reached. At the base of the alluvium was found a foot or so of hard black loam with fresh-water shells and fragments of Jurassic fossils derived from the Boulder-clay.

In working out the material afterwards, it became evident that from top to bottom the alluvial deposits below the Palæolithic brickearth belonged to one series, the same plants occurring throughout. Hence there were only two deposits to deal with—a stony brickearth yielding little or nothing but Palæolithic implements, and a series of ancient alluvial deposits below, full of plants and shells, but, as far as known, without trace of man. The mammalian remains were all said to come from the whitish marly silt which occurs locally immediately below the Palæolithic brickearth. They are mostly in Mr. W. Ransom's collection, and were determined by Mr. Sanford. The remainder of the animals and plants, with the exception of two species of mollusca, were obtained in the trial-pit just described. For the determination of the fishes, the author was indebted to Mr. E. T. Newton, and for the mosses to Mr. W. Mitten; the mollusca and flowering plants were identified by Mr. Reid himself.

MAMMALS.—*Ursus; Equus caballus*, Linn.; *Rhinoceros; Hippopotamus* (a waterworn bone); *Cervus elaphus*, Linn.; *Elephas primigenius*, Blumb.

FISHES.—*Perca fluviatilis*, Linn.; *Esox lucius*, Linn.; *Leuciscus rutilus*, Linn.; *Leuciscus erythrophthalmus*, Linn.; *Tinca vulgaris*, Cuv.

INSECTS.—Elytra of several genera of beetles, badly preserved; Galls.

MOLLUSCA.—*Helix pulchella*, Müller; *Clausilia biplicata*, Mont.; *Carychium minimum*, Müller; *Planorbis albus*, Müller; *Planorbis carinatus*, Müller (recorded by Mr. E. T. Newton); *Planorbis complanatus*, Linn.; *Planorbis nautileus*, Linn.; *Planorbis nitidus*, Müller; *Planorbis spirorbis*, Müller (found by Mr. A. S. Kennard); *Limnæa auricularia*, Linn.; *Limnæa peregra*, Müller; *Limnæa stagnalis*, Linn.;

Velletia lacustris, Linn.; *Valvata piscinalis*, Müller: *Valvata cristata*, Müller; *Bythinia Leachii*, Shepp.; *Bythinia tentaculata*, Linn.; *Pisidium pusillum*, Gmel.; *Sphærium corneum*, Linn.; *Anodonta*.

Flowering Plants.—*Ranunculus aquatilis*, Linn.; *Ranunculus sceleratus*, Linn.; *Ranunculus repens*, Linn.; *Montia fontana*, Linn.; *Prunus spinosa*, Linn.; *Poterium officinale*, Hook. f.; *Pyrus torminalis*? Ehrh. (identical with seeds found at Hoxne); *Hippuris vulgaris*, Linn.; *Myriophyllum*; *Cornus sanguinea*, Linn.; *Sambucus nigra*, Linn.; *Eupatorium cannabinum*, Linn.; *Fraxinus excelsior*, Linn.; *Menyanthes trifoliata*, Linn.; *Lycopus Europæus*, Linn.: *Ajuga reptans*, Linn.; *Alnus glutinosa*, Linn.; *Quercus robur*, Linn.; *Ceratophyllum demersum*, Linn.; *Sparganium*; *Potamogeton crispus*, Linn.; *Potamogeton*, sp.; *Potamogeton*, sp.; *Naias marina*, Linn.; *Scirpus lacustris*, Linn.; *Scirpus*, sp.; *Carex*.

Mosses.—*Antitrichia curtipendula*, Brid.; *Homalothecium sericeum*, Bry. Europ.; *Hyocomium brevirostre*? Bry. Europ.; *Isothecium*?; *Neckera complanata*, Bry. Europ.; *Stereodon cupressiformis*, Brid.; *Zygodon*?

Characeæ.—Several species indet.

Such trees as the oak, ash, sloe, cornel, elder, and alder point unmistakably to a temperate climate, and the fauna and flora as a whole suggest climatic conditions not differing greatly from those we now enjoy. Mr. Mitten writes of the mosses, that "all these are inhabitants of a sylvan temperate region . . . . and none point to a different environment from that now existing; they are not Arctic." The occurrence of *Naias marina*, now only found in Britain in two of the Norfolk Broads, is singular, although the plant was evidently more common in former times than at the present day. It has now been discovered in the Pre-Glacial deposits of Norfolk and Suffolk, beneath Palæolithic remains at Hitchin, and in a submerged land-surface of Neolithic date at Barry Docks, in South Wales.

The resemblance of the Hitchin Palæolithic brickearth to the Palæolithic brickearth of Hoxne, and the similarity of the old alluvia beneath, both in fossil contents and in the physical changes they suggest, are so striking that one is compelled to correlate them bed by bed. If, however, this correlation be correct, it is evident that the intermediate deposit full of leaves of Arctic willows, so conspicuous over part of the area at Hoxne, is missing at Hitchin. At each locality the same story is told. Some time after the passing away of the ice the land stood higher than now, so that the streams had a greater fall and valleys were cut to a somewhat greater depth. Then the land sank and the valleys became silted up with layer after layer of alluvium, to a depth of at least 30 feet, the climate remaining temperate. The next stage, when an Arctic flora reappeared, is only represented at Hoxne. The third stage in the infilling of the valleys is shown in the curious unstratified decalcified brickearth with scattered stones and Palæolithic implements, identical in character at Hitchin, Hoxne, Fisherton, and other localities, which irresistibly suggest a mingling of wind-transported material and rainwash.

It may be pointed out that if this hypothesis of the origin of the Palæolithic brickearths during the reign of "steppe" conditions be accepted, it will account for the non-correspondence of the ancient channels with the present valleys, a thing very difficult to explain if the infilling were caused by ordinary fluviatile action. If the Palæolithic brickearth be equivalent to the Palæolithic loess of the ancient deserts in Central Europe, it can be understood how during this period of cold drought the smaller streams ceased to flow and their valleys became so filled with rainwash and dust that when a moister climate recurred the streams had to seek new channels.

REVIEWS.

I.—ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM, AND OF THE MUSEUM OF PRACTICAL GEOLOGY, FOR THE YEAR 1896. By Sir ARCHIBALD GEIKIE, D.C.L., F.R.S., Director-General. 8vo. (London: Eyre & Spottiswoode, 1897.)

THE Annual Report of the Director-General of the Geological Survey since 1892 has contained particulars of the scientific and practical results obtained during the progress of the field-work, and by the officers of the palæontological and petrographical departments. Hitherto, however, the Report has been published only in the more bulky Report of the Department of Science and Art; and although reprints of the portion relating to the Geological Survey have been distributed, they could not be purchased separately by the general public. A new departure has now been made, and the present Report is published at the price of 6*d.*, and in advance of the larger departmental volume.

Occupying 107 pages of closely printed matter, this Report needs the index which has been added to it. A considerable amount of detail relating to all branches of geology, but more particularly to petrographical researches on the ancient schists, and on various other metamorphic and igneous rocks, will be found. Nearly all formations from those of Pre-Cambrian age to the Recent are dealt with, and some facts relating to the Antiquity of Man, to Lake Basins, and other controverted subjects, are included. The Report being in itself a summary of the observations made by the officers engaged on the Geological Survey, it is impossible here to do more than call attention to the publication, which will doubtless find its way into the hands of all working geologists.

II.—CATALOGUE DES BIBLIOGRAPHIES GÉOLOGIQUES. Par EMM. DE MARGERIE. 8vo; pp. xx, 733. (Paris, 1896. Issued April, 1897.)

THIS Bibliography of Geological Bibliographies is probably the most valuable and useful work that has been issued under the auspices of the "Congrès Géologique International." It contains 3,918 references to lists and catalogues of papers, to papers and memoirs containing copious references to geological literature, and to memoirs and obituary notices of geologists all over the world.

There are indices to authors, principal subjects, and places. If, however, we want a reference to a memoir, say of Wm. Smith, we must search for it under "Biographies de Géologues—Anglais," in the table or index of principal subjects. If we want a list of works on the geology of Lancashire, we must turn to references under "Grande-Bretagne" in the "Table Géographique." The list of authors is no doubt useful, but we think it would have been much more advantageous to index the Memoir of Wm. Smith under Smith than under John Phillips; and the list of papers on Lancashire, under Lancashire, rather than under Whitaker and Tiddeman. For ready reference we want, in fact, fuller indices to subjects and places. It is, however, ungracious to find fault with a work that in all other respects is full and accurate. Geologists will do well to turn over the pages of this volume and take note of the books and memoirs that relate to their special subjects of study, and many will be surprised to find how much useful bibliographic work has been done. Of such work no example will probably be more used than the volume before us, and all geologists will feel indebted to M. de Margerie for the great care and labour he has bestowed on the Catalogue.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—March 24, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "Notes on some Volcanic and other Rocks which occur near the Baluchistan-Afghan Frontier, between Chaman and Persia." By Lieut.-General C. A. McMahon, V.P.G.S., and Captain A. H. McMahon, C.I.E.

In the first part of this paper Captain McMahon describes briefly the physical geography of the Baluchistan deserts, which extend along the south of the Helmund River, between Quetta and Persia. Taking first the plains and their drainage-system, he shows how the wide alluvial plains of Shorawak and Chagai were probably in earlier times one large lake. North and west of these plains, as far as Persia, lie vast deserts of sand, which in places are gradually encroaching upon and burying the mountain-ranges which rise up like islands in the desert. He shows how the sand has intercepted all the drainage from the mountains and prevented it from making its way, as it would otherwise do, into the Helmund River and the God-i-Zirreh Lake. Turning next to the mountains, Capt. McMahon describes a well-defined line of fault, which he traced for a distance of about 120 miles from north of Chaman, along the Khwaja Amran and Sarlat mountain-ranges to Nushki. East of this fault all the rocks appear to be sedimentary; while those to the west are all, with few exceptions, volcanic and igneous.

The mountain-ranges in the desert described appear to be all volcanic, and reference is made to the Koh-i-Taftan, 12,600 feet high, lying south-west of them, which is still an active volcano.

The curious, grotesquely-shaped peaks of the Koh-i-Sultan range are then briefly described, and especially that named Neza-i-Sultan —a gigantic natural pillar of volcanic agglomerate many hundreds of feet high.

After thus describing the general character of the country, Captain McMahon points out the very remarkable force and activity with which certain natural agents are at present at work there—namely, water, wind, sand, and extremes of heat and cold.

In the second part of the paper General McMahon describes the microscopical characters of the rocks, which consist of lavas, ashes, pumice, igneous intrusive, and sedimentary rocks. The localities in which ores of lead and copper, gypsum, sulphur, etc., occur abundantly are also mentioned.

Some andesites are described, which are especially interesting from a petrological point of view. Rosenbusch mentions that a brown hornblende occurs in some rocks in which the angle of extinction varies from small to *nil.* Some of the andesites described abound in amphibole, red-brown in transmitted light, which possesses the optical properties and specific gravity of anthophyllite, and which uniformly exhibits straight extinction. It is an original and not a secondary mineral.

These anthophyllite-bearing augite-andesites also contain olivine —a mineral rare, but not unknown, in this class of rocks.

2. "On the Association of *Sigillaria* and *Glossopteris* in South Africa." By A. C. Seward, Esq., M.A., F.G.S., University Lecturer in Botany, Cambridge.

In this paper the author describes in detail several specimens of fossil plants submitted to him by Mr. David Draper, of Johannesburg. His conclusions as to the geological age of the plant-bearing beds differ from those arrived at by Mr. Draper from stratigraphical evidence; the plants point to an horizon which may be referred to what is now termed the Permo-Carboniferous age. The difficulty of distinguishing between various forms of *Glossopteris*-leaves is discussed at some length; and the opinion expressed that it is practically impossible to separate the Indian, Australian, and African forms of *G. Browniana*, *G. indica*, and others. The chief interest as regards the plants centres round the specimens of *Sigillaria*; these are fairly well preserved impressions, and are referred to the well-known species, *S. Brardi.* In addition to various forms of the genus *Glossopteris* and the specimens of *Sigillaria*, the following plants are recorded:—*Noeggerathiopsis Hislopi*, *Gangamopteris cyclopteroides*, *Phyllotheca*, *Conites* sp., *Cardiocarpus* sp., and *Sphenopteris* sp.

The paper concludes with some general remarks on botanical provinces in the Northern and Southern Hemispheres, and the relation of the *Glossopteris*-flora to the Coal-measure vegetation of Europe.

3. "Notes on the Occurrence of *Sigillaria*, *Glossopteris*, and other Plant-remains in the Triassic Rocks of South Africa." By David Draper, Esq., F.G.S.

The author gives a brief description of the geology of four localities, within a comparatively short distance from Johannesburg, from which several fossil plants have recently been obtained. He considers the plant-bearing beds to belong to the Lower Stormberg Series of Dunn, and to the horizon known as the Molteno Beds. The most important locality described in these notes is that of Vereeniging, 30 miles south of Johannesburg, where the author found several specimens of *Sigillaria* associated with *Glossopteris* and other plants in iron-stained sandstones. The significance of this discovery of *Sigillaria* is briefly discussed. The several species of plants have been described by Mr. A. C. Seward in a paper recently sent to the Society.

II.—April 7, 1897.—Dr. Henry Hicks, F.R.S., the President, left the Chair, which was taken by Prof. Bonney, D.Sc., F.R.S., V.P.G.S. The following communications were read:—

1. "On the Morte Slates and Associated Beds in North Devon and West Somerset.—Part II." By Henry Hicks, M.D., F.R.S., P.G.S. With Descriptions of the Fossils by the Rev. G. F. Whidborne, M.A., F.G.S.

In the first part of this paper, read by the author before the Society in February, 1896, he described the Morte Slates as they occur in North Devon, and the fossils found in them. In this, the second part, he refers mainly to the rocks classified as Morte Slates in West Somerset He shows that the latter differ in some important characters from those in North Devon, and have an entirely distinct fauna. The fossils obtained from North Devon show that there the beds must in the main be classed with the Silurian rocks; but in West Somerset, so far as discoveries have yet been made, the fossils indicate that they should be classed with Lower Devonian rocks. The author's contention that the Morte Slates which extend through the centre of North Devon and West Somerset from Morte Point to the north of Wiveliscombe, a length of about 40 miles, are the oldest rocks in the area and form an axis with newer rocks lying to the north and to the south, is therefore fully proved by stratigraphical and palæontological evidence. The fossils are carefully described by Mr. Whidborne, and he shows that there are numerous forms in common between them and those considered to be characteristic of the Lower Devonian rocks in the continent of Europe and in America.

The President then resumed the Chair.

2. "The Glacio-Marine Drift of the Vale of Clwyd." By T. Mellard Reade, Esq., C.E., F.G.S.

The local drift of the higher parts of the Vale of Clwyd is replaced by marine drift towards the mouth; and it is the object of this paper to give the results of a detailed examination of these marine drifts, rather than to explain the phenomena. The first part of the paper gives the results of an examination of the Boulder-clay from Craig, west of Llandulas, to the Vale of Clwyd, south-east of Abergele.

Mechanical analyses of the clays are given; but the point of greatest interest is the occurrence of abundance of Foraminifera, especially in the plastic brown and red Boulder-clays, which often contain intensely striated erratics. These Foraminifera have been examined by Mr. Joseph Wright. Most of them occur in the Boulder-clays of Crosby and Wirral; but some of them are very rare in British localities other than those now recorded, namely, *Rhabdogonium tricarinatum*, *Sphecoidina bulloides*, *Pullenia sphæroides*, and *Pulvinulina Menardii.*

The glacial sands and gravels of the east side of the Vale of Clwyd are also described, and especial attention is called to an esker-like mound of sand (gravel), occurring south-east of Diserth Castle, formed of bedded deposits, the bedding of which generally follows the outer form of the ridge. The ridge has Boulder-clay upon the flanks, and is described as rising through the Boulder-clay.

III.—April 28, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Origin of some of the Gneisses of Anglesey." By Charles Callaway, M.A., D.Sc., F.G.S.

The author still maintains the occurrence of two Pre-Cambrian groups in Anglesey, the latter of Pebidian age. In the present paper a description is given of the production of gneissic structure in the rocks of the earlier group occurring in the south of the island. The products of metamorphism are similar to those described by the author in the Malvern area. (i) Simple schists, granite is converted into mica-gneiss, diorite into hornblendic or chloritic gneiss, and felsite into mica-schist; (ii) Injection-schists. In Anglesey felsite plays the part which is taken by granite at Malvern, and certain important differences arise. Gneiss of primary injection is formed by the parallel veining of felsite and diorite, and the author describes cases; he also notices the occurrence of metamorphosed diorite-blocks in grey gneiss, which afford evidence of its eruptive origin. Gneiss of secondary injection is well seen in the Llangaffo cutting, and is explained in a manner similar to that given for an infiltration-gneiss at Malvern, felsite being substituted for granite. The infiltration-products are mainly chlorite, iron-oxide, and epidote, and out of the chlorite, with the addition of materials from the felsite, black mica has sometimes been constructed. The changes have occurred along planes of discontinuity formed subsequently to the consolidation of the rocks.

2. "Note on a Portion of the Nubian Desert South-East of Korosko." By Captain H. G. Lyons, R.E. F.G.S. With notes on the Petrology by Miss C. A. Raisin, B.Sc. (Communicated by Professor Bonney, D.Sc., F.R.S., V.P.G.S.) And Water-Analyses by Miss E. Aston, B.Sc. (Idem.)

A general description of the physical structure of the area, which consists mainly of Nubian Sandstone and crystalline rocks, is given. Coming from Korosko to the Murrat Wells, the crystalline rocks are first met with on the east side of Jebel Raft. The strike of these is north and south, whilst to the south of the hill the strike is a few degrees on either side of east and west. At Wadi dur Nabadi are ancient gold-workings, indicated by M. de Bellefonds on his map of the Etbai. The crystalline rocks are both massive and schistose. On the crystalline mass of Jebel Raft, and apparently overlain by the Nubian Sandstone, is a very coarse conglomerate containing fragments of crystalline rock, which appears to be older than the Nubian Sandstone.

The Nubian Sandstone has little or no dip, and shows very slight variation in composition. The water-supply of the Nubian Desert is directly dependent on the rainfall, which is very irregular. The wells are sunk in the detritus of the valleys, and contain a large amount of mineral matter in solution, which renders them almost undrinkable; whilst the second source of supply—the rain-water reservoirs—are deep holes in the ravines which intersect the crystalline hills. These holes must be attributed to water-action; and in the reservoir of Medina in Jebel Raft the spherical stones which assisted in forming the pothole still occur. The author believes that these ravines and reservoirs were formed at an earlier period than the present, when the rainfall was heavier.

Miss Raisin gives accounts of both massive and schistose crystalline rocks, and also of sedimentary rocks. The massive crystallines occur around Murrat and Jebel Raft, and these two areas are separated by the southern mass of schists. Another area of massive crystallines is formed beyond these schists, extending to the head of Wady Allaki. The crystalline rocks described include gneiss, hornblendite, gabbro, diabase, quartz-diorite, granite, felsite, certain schists, and sediments. None of the igneous rocks can be stated with certainty to have originated as a lava-flow. Many of them have undergone much alteration since their consolidation, and the results of this are described. There is clear evidence in many cases of erosion by mud and desert-sand and the formation of a weathered coating. The crystalline schists do not present a very modern facies, and might be late Archæan or early Palæozoic. The massive crystallines may belong to different epochs.

Miss Aston gives two tables, one of which shows the actual amounts of substances found in the wells of Murrat, Bir Tilat Abda, and Bir-Ab-Anaga, whilst the second shows their approximate constitution.

CORRESPONDENCE.

FOREIGN BOULDERS IN THE CHALK.

Sir,—Mr. Martin in your last number suggests that the granite boulders from the chalk-pit at Betchworth, described by Mr. Stebbing, may have come from the south-west. Permit me to say that I know the granites of this part of England, especially that of Hey Tor, fairly well, and for reasons which I think will be obvious to any petrologist who reads my description, consider this place of origin most improbable. Before publishing his speculation Mr. Martin would have done well also to consider the following matters: (1) the height to which the mountains must have risen (supposing the mean temperature to have been the same as now) in order that they could have generated glaciers which would have come down to the sea; (2) whether in this case it is probable that granite would have been exposed at the surface; (3) whether it is probable (looking especially at the evidence of the breccias in the red rocks of Devon) that high mountains existed in this part of England during Cretaceous times. I may add that Mr. Stebbing, so far as I remember his excellent paper, never invoked a Glacial Epoch; that spectre was raised during the debate; nor is it necessary to create a glacier to transport the boulders. Shore-ice, such as forms in the estuary of the St. Lawrence, would be quite adequate for the work. If it started from some northern locality it might readily float down (as slab-ice still does in the Atlantic) well south of the latitude of London.

T. G. Bonney.

FOREIGN BOULDERS IN THE CHALK, AND GASES ENCLOSED IN CRYSTALLINE ROCKS.

Sir,—(1) Referring to Mr. G. A. Martin's interesting suggestion (Geol. Mag., April, 1897, p. 169) that the Betchworth boulder came from Dartmoor, and to its alleged similarity to the granites of Hey Tor and Lustleigh Cleave, the microscope would probably answer this question decisively. Within fifty miles of Hey Tor the floor of the English Channel is strewn with detached blocks of crystalline rocks. Of these blocks I have a large collection of slides, and also a considerable number of specimens from all parts of Dartmoor; collected for the most part by myself, or sent me by the late Mr. R. N. Worth. Not a single specimen of the Channel blocks can be referred to Dartmoor. The minute characters of the Hey Tor and Lustleigh Cleave granites are well marked both positively and negatively. Three of each class of differences will probably suffice—e.g.: presence of fibrous tourmaline; of chloride inclusions in the quartzes; of soda felspar in the large potash felspars;—absence of hornblende; of dislocation of minerals; of any approach to gneissoid structure. Besides these there are others, but most granites not derived from Dartmoor will fail to meet one or other of the above tests.

(2) In the current number of the Geological Magazine (p. 177) Dr. Tilden's paper on Gases enclosed in Crystalline Rocks is shortly reviewed, and mention is made of hydrogen in the Peterhead granite. On seeing this I referred to some notes made in 1890 on a collection of granites which Mr. Teall had kindly lent me to study. Among these notes occur the following, under the heading "Pink Granite of Rubislaw":—"A plane of fracture with fluid inclusions across another with only gas inclusions—order of sequence not made out. Rhombic negatives with bubbles. One negative hexagon with very active bubble. One patch of quartz full of hair-like inclusions and lines of bubbles: in one or two cases the hairs crossing the lines were distinctly divided in two, as seen with $\frac{1}{16}$. Could find no decided cubic crystal; any sort of crystal (in fluid inclusions) extremely rare. Bending in dark micas." Now it is not too much to

say that the above granite is as distinct from the West Country granites as any two species can be. Now for the first time we learn that the Peterhead granite was consolidated in the presence of compressed hydrogen, just as we know that the Dartmoor rock crystallized out of fluids charged with salts. The conditions were different and the minute results are different—very. Those intersecting planes of fracture are significant enough. The Rubislaw granite was consolidated; then cracked and recemented; then cracked again and recemented; and the cements varied in the two cases. In the one, the cementing silica was charged with gas, in the other not apparently so. These facts are patent to anyone who will take adequate pains to see them. The explanations must be left to experts. A. R. Hunt.

April 9, 1897.

OBITUARY.

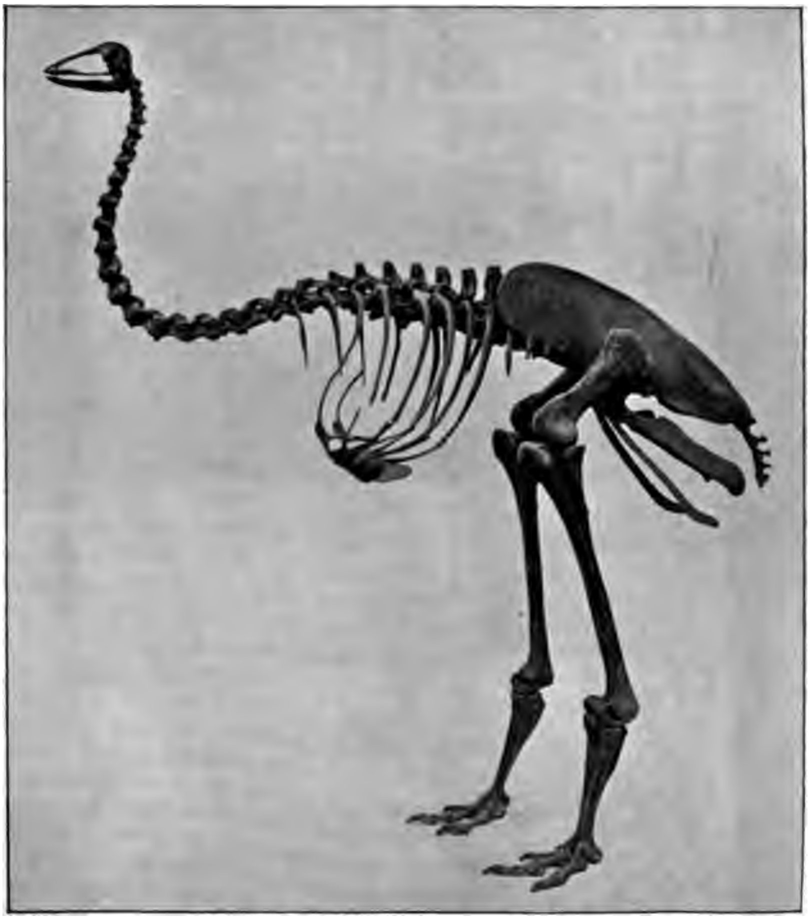
PROFESSOR EDWARD DRINKER COPE, A.M.,

FOR. CORR. GEOL. SOC. AND ZOOL. SOC. LOND.

Born July 28, 1840. Died April 12, 1897.

It is with deep regret that we record the death of Professor E. D. Cope, the eminent palæontologist and comparative anatomist, late of 2100, Pine Street, Philadelphia, Pa., U.S.A. E. D. Cope, who was born at Philadelphia, July 28, 1840, studied in the University of Pennsylvania and worked at anatomy in Europ (in 1863–4). For the three succeeding years (1864–7) he fille the Chair of Professor of Natural Science in Haverford College Philadelphia, and was for some years Curator and Correspondin Secretary of the Academy of Natural Sciences in that city. At th time of his death he held the Chair of Geology and Palæontolog in the University of Pennsylvania. From 1871–7, he carried o explorations in the Cretaceous strata of Kansas; the Eocene o Wyoming; the Tertiary beds of Colorado. He also served on th U.S. Geological Survey in 1874 in New Mexico; in North Montan in 1875; in Oregon and Texas in 1877.

He has accumulated a collection of over 1000 species of extinc Vertebrata, and has made known at least 600 species new to scienc Professor Cope was a voluminous writer, and his papers are publishe in the Proceedings of the scientific Societies of Philadelphia, an in the Reports of the U.S. Geological Survey of the Territorie under Dr. F. V. Hayden and Captain Wheeler. Professor Cope wa an advanced Evolutionist, and his contributions on this subjec have been very numerous. He was the senior Editor of th "American Naturalist," a monthly journal which contains man of his original essays. He was a Foreign Correspondent of th Zoological and Geological Societies of London, and received th Bigsby Gold Medal in 1879 from the latter Society, in recognitio of the genius and skill with which he had enriched the sciences Comparative Anatomy and Palæontology, and the immense an varied work which he had achieved among the fossil Vertebrata.



Restored skeleton of *Æpyornis Hildebrandti*, Burckhardt, from Peat-Deposit, Sirabé, Central Madagascar.

Obtained by Dr. C. I. FORSYTH MAJOR, C.M.Z.S.

Height of skeleton 5 feet 2 inches (= 158 cm.).

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. VI.—JUNE, 1897.

ORIGINAL ARTICLES.

I.—NOTE ON A NEARLY COMPLETE SKELETON OF *ÆPYORNIS* FROM MADAGASCAR.

By C. W. ANDREWS, B.A., B.Sc., F.G.S.,
Assistant in the British Museum (Natural History).

(PLATE IX.)

THE growth of our knowledge of the gigantic extinct birds of Madagascar has been a very slow one. The first notice of their occurrence was published in 1851 by I. Geoffroy St. Hilaire; but it is only within the last two or three years that any part of their skeleton, except the bones of the leg and some very imperfect vertebræ, has been described. Recently, however, the collections that have reached the Museum of Natural History at Paris, and those obtained by Dr. Forsyth Major for the British Museum, have filled most of the gaps, and all the important parts of the skeleton are now known.

The present note is a preliminary account of a nearly complete skeleton, that may for the present be referred to *Æpyornis Hildebrandti,* a species described in 1893 by Burckhardt[1] on the evidence of the bones of the leg and an imperfect pelvis. Unfortunately, this specimen is not composed of the bones belonging to one individual, but has been reconstructed from the immense series of remains collected in the neighbourhood of Sirabé by Dr. C. I. Forsyth Major and his companion, M. Robert, during their recent visit to Madagascar. This collection includes many hundreds of bones, nearly all referable to this species, so that, in spite of the considerable degree of individual variation in size to which these birds are subject, it has been possible to construct a skeleton which must, at least, very nearly resemble one belonging to a single individual.

Many of the more important parts of this specimen, including the skull, sternum, shoulder-girdle, and humerus, have already been described and figured in the *Ibis* for July, 1896, and only their more striking peculiarities need here be noticed, while in the case of the vertebral column and pelvis a somewhat more detailed, but necessarily brief account will be given.

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[1] "Ueber *Æpyornis*": Palaeontologische Abhandlungen, neue Folge, Bd. ii, Heft 2. (Jena, 1893.)

Of the skull no complete specimen is known, but a nearl
cranial portion, the anterior part of the beak, and a mandil
described and figured in the paper above referred to (pl. viii
foramen magnum is large and oval, the occipital condyle pedu
and there is a precondylar fossa. The paroccipital proce
large, but only extend downwards a little below the condyl
lambdoidal crest is weak, and the occipital surface passes
roof of the skull by a gentle curve. The surface of the
is marked by several rows of deep pits which indicate the
of a crest of large feathers. The tympanic cavity is shal
the temporal fossa is very deep and narrow; there is
zygomatic process. The basi-temporal platform is very pro
anteriorly it bears a pair of large basi-pterygoid proces
laterally it is grooved by the eustachian canals, which rem
as in *Dinornis.* There is only a single facet for articulati
the quadrate. This bone is chiefly remarkable for the g
pansion of its orbital process, which forms a broad pl
a rough inner surface in which some pneumatic foramin
The single convex facet for articulation with the cranium
what triangular in outline, and the articular surface for the
is completely divided into two facets, the inner conve
directions, the outer concave from side to side. On the in
of the bone there is a broad surface for union with th
extremity of the pterygoid (γ_1), on the outer a deep cup
posterior end of the jugal arch.

The rami of the mandible are very broad (from side to
massive. The articular surface for the quadrate is deep, a
are well-developed posterior and internal angular processes.

The vertebral column as reconstructed consists of twe
cervicals and eight vertebræ bearing free ribs, of which
the three anterior are cervico-dorsals. The fused pelvic
are about twenty in number. It is, of course, possi
a mistake may have been made in the number of vertebra
far as it is possible to judge by the gradual increase and de
size of the various processes from one region to another, the
as now mounted must be very nearly correct.

In the atlas vertebra, of which a very perfect spec
preserved (Fig. 1, A), the cup for the occipital condyle is
circular in outline: it is nearly complete, the cleft in i
margin being comparatively narrow and only extending do
about one-third of the diameter. The posterior articular s
shaped somewhat like the letter B, the straight border b
dorsal margin, while the two lobes are two nearly co
separated, slightly concave, articular surfaces for the ax
inferior angles of these lobes are produced into short
forming lateral hypapophyses: there is no trace of a
hypapophysis. The neural arch is very large, and its tw
are completely fused above. The pedicels are narrow, but s
the arch is greatly expanded, forming a backwardly projecti
which forks posteriorly into an upper and lower lobe. T

bears on its inner face the nearly circular posterior zygapophysis, which looks inward and backward; above this there is a strongly developed hyperapophysis. The lower lobe consists of a downwardly and backwardly directed process, the base of which is perforated by a large foramen; it seems to be homologous with the process in the atlas of *Rhea*, which is regarded by Mivart as the diapophysis. At the same time the perforation of the base gives it much the appearance of a fused cervical rib, of which the capitulum has shifted up into the arch. The posterior border of the middle of the neural arch is deeply concave: the anterior has been broken away.

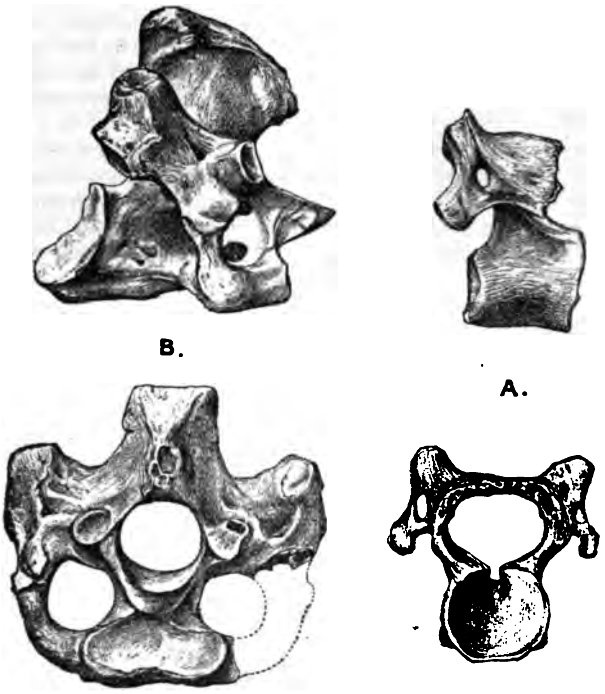

Fig. 1.—A. Atlas of *Æpyornis* from front and side.
B. Axis ,, ,, ,,
All the figures natural size. The axis belonged to a rather larger individual than the atlas.

The atlas thus differs widely from that of *Struthio* in the completeness of the cup for the occipital condyle, the absence of the costal element enclosing a vertebrarterial canal, the presence of a large diapophysis, and the absence of a median hypapophysis. In the first three of these characters it differs also from *Dinornis*. Of the other Ratitæ, *Rhea* most resembles this specimen, in the structure of the atlas, the form of the arch, and in the anterior articulation being closely similar; in *Dromæus* also there is no costal element enclosing a canal. On the other hand, there is a median hypapophysis, and hyperapophyses are wanting. The atlas of *Casuarius* also shows some points of similarity.

In the *axis* the preaxial surface of the centrum is concave from above downward, about three times as wide as high, and imperfectly divided into two facets, corresponding to the posterior articular surface of the atlas. The postaxial surface is of the usual saddle shape, and much higher than wide; it presents somewhat the appearance of two crescents joined back to back, and both its dorsal and ventral borders are deeply concave. The ventral surface of the centrum as far back as the hinder border of the parapophyses is very broad: behind this it becomes laterally compressed, and bears a low hypapophysial keel which extends nearly to its hinder edge. On the broad anterior portion a little behind its anterior margin there is a well-marked transverse ridge extending up on to the fused rib.

The odontoid process is short and broad: on its ventral side, separating its proper articular surface from the upward continuation on to its base of the anterior surface of the centrum, there is a shallow pit for the insertion of a ligament.

The neural arch is a very massive structure, of which the pedicels are very short and broad. The upper border of the neural spine slopes upward and backward, in which direction also it thickens, so that posteriorly it is broad and shows traces of the bifid condition met with in the succeeding vertebræ; its posterior surface bears a deep pit for ligaments. The anterior zygapophyses are merely small circular facets on the anterior border of the arch, from which they scarcely project at all. The posterior ones are very large and look downward and slightly backward; they are surmounted by very large tuberous hyperapophyses. The fused cervical rib enclosing the vertebrarterial canal is greatly expanded at its upper end, and there is a broad interzygapophysial bar and a small interzygapophysial foramen. The inner wall of the vertebrarterial canal bears three large pneumatic foramina, the upper one perforating the arch, the lower the centrum.

The axis above described differs from that of *Struthio* in possessing a much more prominent neural spine and hyperapophyses, a shorter centrum, a much smaller hypapophysis, much larger vertebrarterial canals (in *Struthio* these are very small), and less developed anterior zygapophyses. Moreover, in *Struthio* the posterior articular surface of the centrum is broader than high. It differs from that of *Dromæus* in its rather more prominent neural spine and much smaller hypapophysis, in its larger vertebrarterial canal, and in the presence of an interzygapophysial foramen; from that of *Rhea* in its much smaller hypapophysis and larger vertebrarterial canal, the form of the neural arch being very similar in the two birds; from that of *Dinornis* in its much smaller hypapophysis, the form of its posterior articular surface, the shape of the odontoid process and its articular surfaces, and in the rudimentary condition of its anterior zygapophyses.

The third vertebra, seen from above, has the usual quadrate form, but the width is greater than the length as in *Dinornis*, instead of the reverse as in *Struthio*. The anterior articular face of the centrum looks completely downward; it is much narrowed in the middle by a fossa which forms a deep emargination in its hinder border. The posterior articulation is similar to that of the axis, but wider in proportion to its height. The ventral surface, deeply concave from side to side in front, becomes narrower posteriorly and bears a hypapophysial keel. The anterior and posterior zygapophyses are both large and nearly equal in size, and there are large hyperapophyses over the posterior ones. The interzygapophysial bar is broad and there is an interzygapophysial foramen. The neural spine consists of a broad basal platform, increasing in height posteriorly and bearing on its posterior surface a pit for ligament. Superiorly it is bifid, rising into two prominent tuberosities separated from one another by a deep groove. Between these processes and the hyperapophyses there is a broad valley.

The fourth vertebra is very similar to the third, except that the posterior articulation of the centrum is broader. The fifth is also similar, but the neural spine is rather higher. In vertebræ 4–6 the anterior zygapophyses look upward and forward, making an angle of about 45° with the long axis of the column; they are not directed at all inwards. In the sixth the transverse bar of the neural spine is reduced, while its bifid extremity increases in height; at the same time the spine is shifted towards the anterior border of the neural platform, which here commences to increase in length; the hyperapophyses are much smaller, and the interzygapophysial bar is reduced. In the centrum the articular surfaces are much broader than high, and the hypapophysis is reduced to a small ridge near the middle of the ventral surface. The seventh is similar to the sixth, but shows traces of the narrowing of the posterior region of the neural platform, which is the most remarkable character of the eighth.[1] In the eighth the anterior half of the neural platform is more than twice as wide as the posterior. The neural spine, as before, consists of a basal portion bearing a bifid extremity; but it is farther forward and is united on either side to the hyperapophysis by an oblique ridge. The posterior zygapophyses now look outward as well as downward and backward. The centrum is very broad, and there is no trace of a median hypapophysis. In the ninth the neural spine is represented only by the anterior portion of the ridges (neural or postzygapophysial), which run forward from the hyperapophyses, converging towards the middle point of the anterior margin, where they meet in a slight prominence; in the angle between these ridges there is a deep pit for ligament. Behind the anterior zygapophyses there is a pocket-like fossa, into which open pneumatic foramina.

The next ten vertebræ resemble the ninth in general character. The chief modifications that are perceptible in the successive vertebræ are—(1) The neural or postzygapophysial ridges become higher and at the same time do not extend so far forward. (2) On the eleventh there are small paired hypapophyses on the ventral surface of the centrum; in the twelfth these unite, forming a low median tuberosity, which increases in height to the seventeenth, behind which it also increases in antero-posterior extent, until on twenty and twenty-one it forms a keel more than half the length of the centrum. In all these vertebræ the centrum is broad and the articular faces much wider than high.

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[1] It may here be remarked that it is possible that a vertebra too many may have been used in reconstructing this anterior portion of the neck.

On all the cervical vertebræ the fused ribs are very broad, and enclose a large vertebrarterial canal.

The next vertebra (21) is the first with a free rib, and both it and the succeeding two may be regarded as cervico-dorsals. In these the anterior portion of the neural ridges are united by a broad base and again rise to form a bifid neural spine. In the last cervico-dorsal, however (23), the basal portion of the spine increases in height, while the bifid part is relatively smaller; in the next (24) the spine is a massive quadrate structure, which shows only a trace of the bifid condition at its upper end, and in the following vertebræ it increases in height and antero-posterior extent. In all the dorsal vertebræ the spine bears on its anterior, posterior, and lateral surfaces vertical ridges, which in their lower portion expand into thin buttresses of bone: of these the anterior runs forward to the middle point of the anterior border of the neural arch, the lateral outward to the diapophysis, the posterior, which is the smallest, to the middle point of the posterior border of the arch. On 23–28 inclusive there is also a pair of postero-lateral buttresses which run outward and backward on to the posterior zygapophyses; in 23–26 these ridges terminate in a small hyperapophysis: they are homologous with the posterior portion of the neural or post-zygapophysial ridges. In all these vertebræ between the bases of these plate-like buttresses there are deep pocket-like fossæ.

In the cervico-dorsal and dorsal series the diapophyses become less massive and project farther laterally as we pass backwards, and at the same time the pneumatic fossa occurring at their base increases in size. In these vertebræ the antero-lateral margin of the centrum forms a prominent lip which bears a deep capitular facet; in the cervico-dorsals this is circular, in the dorsals it is elongated from above downward and forward. These vertebræ have on their ventral surfaces prominent keel-like hypapophyses, which in the posterior ones are directed forward and occupy almost the whole length of the centrum.

The first pelvic vertebra has a high massive neural spine, the quadrate upper end of which is exposed between the divergent anterior ends of the ilia. Its transverse process is single (diapophysis), and unites with the ilia by its expanded outer end: it bears a facet for the tubercle of the free rib, the head of which articulates with a facet on the anterior margin of the centrum. There is some indication of a median hypapophysis, and both the side of the centrum and the base of the diapophysis are perforated by large pneumatic fossæ, which are separated only by a thin horizontal plate of bone. In the second pelvic the top of the neural spine is completely fused with the ilia, as also are those of the other preacetabular vertebræ, thus forming a high iliac crest, which is convex from before backward. The second vertebra also has only the diapophysis developed, and bears a free rib; there is in this case a well-marked blunt hypapophysis. In the third the costal element is fused with both the diapophysis and parapophysis, and forms a pointed process projecting below the ventral margin of the ilium. The next three vertebræ have double transverse processes. As far back as this point (i.e., to the hinder border of the sixth pelvic vertebra) the ventral surface of the sacrum is convex from side to side, and its long axis is nearly straight, but behind this it becomes concave from side to side and strongly convex from before backward, and opposite the origin of the free portion of the ischium it turns sharply dorsad and then again runs backward nearly in a straight line, sloping somewhat upwards. The ventral convexity occurs at the level of the acetabulum, and the vertebræ of this region are fused into a solid mass, the only traces of the compound origin of which are a few small foramina, which mark the intervals between the parapophyses, the outer ends of which are completely co-ossified with the pubes and ischia, with the ventral surface of which the ventral surface of the sacrum forms a continuous curve.

The pelvic vertebræ posterior to the convexity are six or seven in number. They bear broad, thin, transverse processes, of which the two or three anterior ones slightly overlap one another, and the outer ends expand and unite closely with the thickened inner border of the ilia. The ventral surface of the centra of the anterior ones is convex from side to side, but that of the posterior is flat or even slightly concave. In these posterior vertebræ the transverse processes and the neural spine form a continuous nearly semicircular plate of bone, which is convex in front and concave behind, and the outer edge of which unites firmly with the ilia. The anterior free caudals are similar in structure; their centra are procœlous and perforated ventrally by a pair of pneumatic foramina: a pair of foramina also penetrate the base of the transverse process. In the more posterior caudals the massive neural spine and transverse processes are not united into a common plate of bone, and the ventral pneumatic foramina are wanting; their centra are deeply cupped in front.

In the pelvis the preacetabular portions of the ilia are inclined to one another at a very acute angle; as already mentioned, they fuse along their dorsal margin with the tops of the neural spines of the anterior pelvic vertebræ, thus forming a high massive iliac crest, convex from before backward. At about the level of the acetabulum the ilia begin to diverge and are divided by a prominent angular ridge into a superior surface, which together with the broad united upper ends of the neural spines forms a wide pelvic escutcheon, and a lateral surface which is nearly vertical. The pelvic escutcheon is convex from side to side and is constituted mainly by the expanded upper portions of the neural spines of the sacral vertebræ, the original divisions between which are indicated by an outer and inner row of inter-osseous foramina, the outer marking the boundary between the vertebræ and the ilia, the inner running close to the middle line; between the two there is a shallow depression with sharply defined margins, which seems as if it may have lodged an ossified tendon. The ilia terminate posteriorly in an angle which lies some distance behind the last fused caudal vertebra. The nearly vertical external surface is extended downward as a thin flange of bone, the straight lower edge of which is, in one specimen, almost in contact with the straight upper margin of the expanded portion of the ischium; this ventral flange extends some distance below the centra of the fused caudal vertebræ. The acetabulum is large and its anterior edge is produced outward into a prominent preacetabular process. The ischium is proximally a trihedral rod, but its distal portion is greatly widened by the presence of wing-like expansions of its upper and lower borders, the upper being much the larger and, in one specimen, having for some distance a straight upper border which is nearly in contact with the ilium, the two bones being separated only by a narrow slit for about 12 cm.; the greatly expanded distal portion extends some distance behind the ilia. The ischium also bears on its ventral margin a small process, which nearly meets the pubis and closes the obturator foramen.

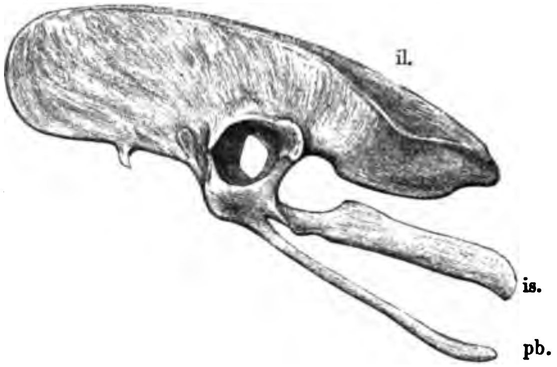

FIG. 2.—Pelvis of *Æpyornis Hildebrandti*, Burckh.; reduced to between one-eighth and one-ninth nat. size. *il.* = ilium, *is.* = ischium, *pb.* = pubis. (In another pelvis the distance between the ilium and ischium is only three millimetres at the narrowest point.)

The pubis is a long curved rod, triangular in section, with one of the sides of the triangle forming the external surface. For a great part of its length the upper and lower angles are produced into narrow thin plates of bone; distally the bone is somewhat expanded. Both the pubis and ischia of opposite sides diverge from one another, so that the posterior opening of the pelvis is very wide.

There seem to have been ten pairs of free ribs: the first three, borne on vertebræ 21–23, are not connected with the sternum, to which the next four are joined by sternal elements. The last dorsal bears a free rib, as also do the first two pelvic vertebræ. On none of the ribs are there any uncinate processes.

The ratite sternum is of very peculiar form, and has undergone great reduction. It is a thin plate of bone, very wide from side to side, and extremely short from before backward, especially in the middle line. It has well-developed coracoid grooves and prominent antero-lateral processes, at the base of which pneumatic foramina open. It is very unlike the sternum of any other ratite bird except *Apteryx*, but this similarity is probably due to the fact that in both cases the bone has undergone extreme retrogression.

The sternum has been figured on pl. ix of the above-mentioned paper.

The coraco-scapula is not unlike that of *Casuarius*. It consists of a broad ventral plate, the *coracoid*, and a dorsal curved rod-like region, the *scapula*, the two making a very obtuse angle with one another, and being completely fused in the adult. The coracoid is perforated in its upper portion by a large supracoracoid foramen, and articulates with the coracoid groove of the sternum by a long straight ventral border. There is a blunt precoracoid process. The upper extremity of the scapula is flattened and somewhat expanded. On the outer border of the compound bone, at the junction of the two elements, there is a small but very clearly-marked glenoid cavity. The coraco-scapula has been figured loc. cit., p. 386, fig. A.

The wing in these birds was reduced to a mere rudiment, and probably scarcely any trace of it was visible externally. The *humerus* is a short rod of bone, the upper end of which bears a rounded articular head and a mere trace of the pectoral crest. The lower end has not the usual surfaces for articulation with the radius and ulna, but only a single one. The remainder of the wing is not certainly known, but in Dr. Forsyth Major's collection there is a bone which I believe to represent the radius, ulna, metacarpus, and phalanges, greatly reduced and fused into a common mass. This remarkable structure bears on its thickened proximal end an articular cup, into which the distal articulation of several of the rudimentary humeri fits very well. Just beyond the articular end the outer surface bears a deep depression in the middle line, indicating, as I believe, the position of the division between the radius and ulna. Distally the bone becomes thin and plate-like, and terminates in an irregular bifid extremity; this portion probably consists of the last remnants of the metacarpus and phalanges.

The complete bones of the hind limb from Sirabé have never been heretofore described and figured, with the exception of the metatarsus, but I can only refer briefly to them on this occasion. The femur is a stout massive bone, of which the head is nearly spherical and the neck short and thick. The trochanter is very large; its upper surface slopes steeply up from the neck, and rises high above the head; anteriorly it forms a very large projection. The upper part of the shaft is rounded, but farther down it becomes somewhat flattened from before backward. The condyles project far forward, and the outer extends considerably below the inner. There is a deep popliteal fossa into which pneumatic foramina open; there is also, in most cases, a pneumatic opening at the upper end of the bone on the posterior surface. In the tibio-tarsus there is a large cnemial crest, which rises considerably above the proximal articular surface. The shaft is compressed from before backward, and its anterior face is much flattened, particularly in its lower half; there is no bony extensor bridge. The distal articulation is very broad, and the two condyles are not separated by a deep intercondylar groove, but form a continuous cylindrical surface.

In the metatarsus the proximal articular surface is very wide from side to side, and narrow from before backward: there is no intercondylar tubercle. The hypotarsus is simple, and forms a very high ridge on the posterior surface of the upper portion of the bone. The anterior face is deeply concave above, but narrows and becomes nearly flat anteriorly a little above the distal articulation. The trochleæ are very large: the inner arises at a somewhat lower level than the outer, and extends farther downward. There is no perforation for the tendon of the adductor of the outer digit.

The toes of the present specimen seem to be relatively rather too small, although some of the largest phalanges were used for their reconstruction. The phalanges are compressed from above downward in the middle and outer toes, while in the inner they are more cylindrical. The ungual phalanges are broad, slightly curved, bluntly pointed claws. In the collection no bones that can be regarded as having belonged to a hind toe occur, but the markings on the hinder surface of the metatarsus seem to show that at least a rudimentary hallux must have been present.

Some approximate measurements of the skeleton as mounted are given below :—

	cm.
Height to top of crest of ilium	116
Height to middle of acetabulum	96
Height to top of skull	158
Length of femur	31
Width of lower end of femur	12
Length of tibio-tarsus	56·5
Width of lower end of tibio-tarsus	10·5
Length of metatarsus	29
Width of upper end of metatarsus	11
Width of lower end of metatarsus	10·5
Width of middle trochlea	4·5
Length of ilia	56
Width of pelvis at anti-trochanter	25
Least preacetabular width	17·5
Length of free portion of ischium	28·5
Distance between distal ends of ischia	30
Distance between distal ends of pubes	33
Height of first pelvic vertebra	17

II.—*BALTOCERAS*, A NEW GENUS OF THE FAMILY ORTHOCERATIDÆ.

By GERHARD HOLM.

A NEW Cephalopodan species, *Endoceras Burchardii*, was described in 1880 by Dewitz,[1] who considered this species as a very typical *Endoceras*. A description and diagram of its ectosiphon is given in the introductory description of the siphon of *Endoceras* as an example of a typical *Endoceras*-siphon. In *Endoceras Burchardii* each septum, according to Dewitz,[2] forms a septal tube (funnel), extending backwards to the next septum, into the septal tube (funnel) of which a small part of it enters.

Rüdiger[3] has also described this species as an *Endoceras*, and I have myself, on the authority of Dewitz, occasionally mentioned it under this name. Having had, however, many opportunities of seeing it in the island of Öland, where it is pretty common in the grey *Lituites* Limestone, I have long since been surprised to find that detached siphons of it—without reference to its size or its marginal position—far more resemble the siphon of an *Orthoceras* than that of an *Endoceras*, not only as to shape but also as regards substance and colour. Like a siphon of an *Orthoceras*, detached by weathering, it never shows any septal fractures,[4] but immediately behind each septum there is a narrow, deep, groove-like contraction, sharply defined in front as well as behind. In figures 2 and 2*a*, taf. xvi, Dewitz, this can be seen very distinctly. Rüdiger, too, has noticed this siphonal form, so exceptional in an *Endoceras*, and describes it thus: "Die Erweiterung der Düten erstreckt sich über den ganzen Zwischenraum zweier Kammerscheidewände, so dass der Sipho nur an der Durchbruchsstelle der letzteren eingeschnürt erscheint und, isolirt, einer Reihe Semmeln ähnelt." Nor does the weathered siphon consist of a firm shell-substance, but always presents itself more or less decomposed, the surface being of an earthy appearance, like that of an *Orthoceras*. Having commenced some time ago to prepare thin sections of a series of species in order to study microscopically the siphons of the Lower Silurian Cephalopods, I was deeply interested as I looked forward to the first section of *Endoceras Burchardii*, and I was not astonished to find its siphonal structure entirely different from that of *Endoceras*; instead, it was quite similar to the siphon of a species belonging to the group *Ellipochoanoida*, Hyatt.

The following illustrations, Figs. 1 and 2, drawn from sections, show the structure of the ectosiphon. The septa, together with the short septal tube (funnel), consist of two layers; one thicker in the middle, of water-clear, colourless calc-spar, on both sides of which there is a thin opaque layer of a light greyish-yellow colour. The septa, therefore, corresponding to the different layers, are white in the figures, with black boundary-lines. The wall connecting the septal tubes (funnels) is of about the same colour and appearance as the outer layers of the septa (like them black in the figures). The loculi are filled with coarse-grained calc-spar; the siphon with the rocky substance. The septal tubes (funnels) are short, and extend only the fifth of the distance to the next septum, ending in a sharp edge. The intervening connective wall is thicker than the septa, opaque, sharply defined inwards, while the outside, even where the specimens are not weathered, is decomposed, having no even or clear-cut surface. At the posterior part it attaches itself to the inner side of the posterior septal tube (funnel); in the anterior part it encloses the outer side of the anterior septal tube (funnel). The strictures and the peculiar appearance of loose siphons is thus easily explained, as the siphon between the septal tubes (funnels) is easily removed from the enclosing stone and from the short septal tubes (funnels). The strictures are therefore impressions from the septal tubes (funnels).

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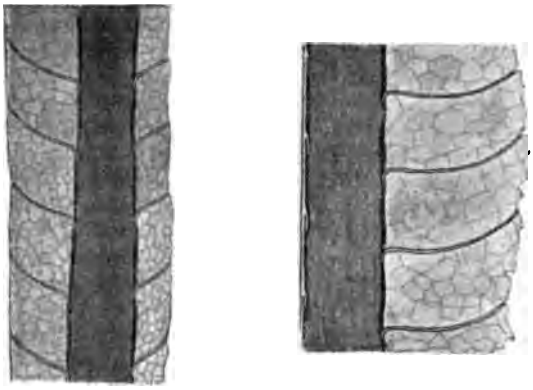
[1] Dewitz, H., "Ueber einige ostpreussische Silurcephalopoden": Zeitschr. d. Deutschen geolog. Gesellschaft, vol. xxxii (1880), p. 391, taf. xvi, figs. 2, 2*a*.

[2] Ibid., p. 371, fig. 1, "Schematischer Längsschnitt in der Mittelebene."

[3] Rüdiger, H., "Ueber die Silur-Cephalopoden aus den mecklenburgischen Diluvialgeschieben," p. 29: Separatdr. aus Arch. der Freunde d. Naturg. Meckl. 1891.

[4] Holm, G., "Om de endosifonala bildningarna hos familjen Endoceratidæ": Geol. Fören. Förh., Bd. xvii (1895), p. 607.



Endoceras Burchardii, Dew. The island of Öland, Grey *Lituites* Limestone.

FIG. 1.—Tangential section through the middle of the siphon. The plane of the section is not exactly at right angles to the middle plane of the conch, nor is it exactly parallel to the longitudinal axis of the siphon. The latter circumstance is the reason why the siphon appears to taper towards the distal end. Drawing after a photograph. Enlarged three diameters.

FIG. 2.—Section in the middle plane. Enlarged two diameters.

In spite of its apparent resemblance to *Endoceras*—through the comparatively large and marginal siphon (diam. $\frac{2}{5}$–$\frac{2}{7}$ of that of the conch)—it appears that the species above described, considering the structure of the ectosiphon, does not even belong to the same subdivision (*Holochoanoida*, Hyatt) of Nautiloidea as *Endoceras*, but has its nearest relations in the family Orthoceratidæ of the subdivision *Ellipochoanoida*, Hyatt. It follows that even within the latter family there must occur species with a large marginal siphon, although they have been overlooked on account of their apparent resemblance to *Endoceras*-forms. It being impossible to refer these species to any genus hitherto described, *Endoceras Burchardii* may be considered as the type of a new genus. As a suitable name I propose *Baltoceras*, as the species of this genus appear in the Baltic Silurian. *Baltoceras Burchardii* (Dew.) is found in the Lituite Limestone in the island of Öland and in Dalarne, as well as in the corresponding horizon (Schicht C_1) of Esthonia, where I have discovered it at Kandel, and at Hirro, near Reval.

In the grey *vaginatum* Limestone in the island of Öland, and in Dalarne, I have found a closely connected form with perfectly identical structure of the ectosiphon, but with shallower loculi.

In this connection it may be mentioned that there is reason to suspect that *Endoceras*, nov. sp., and *Endoceras angustisiphonatum* of Rüdiger,[1] far from belonging to the genus *Endoceras*, in reality are some forms of *Orthoceras*, with marginal or submarginal siphon.

III.—ON A NEW SECTION IN THE MIDDLE LIAS OF LINCOLN.

By JOHN H. COOKE, F.G.S.

THE quarrying operations that have been carried out during the last five years at Handley's Pit, Lincoln, have led to the exposure of some very complete and instructive sections in the Middle Lias.

Handley's Pit is situate on the North Cliff, at a distance of about a furlong from the now disused pit of Glaisiers, and immediately below that of the Lincoln Brick Company (late Swan's). When compared with the sequence exposed in Swan's Pit, it affords some interesting details that assist materially in clearing up some of the doubtful points to which Mr. Dalton referred in the Geological Survey Memoir on Lincoln Geology[2] regarding the limitation of the range of *A. margaritatus*, and the occurrence of the Marlstone Rock-bed in the Lincoln District.

The general facies of the rocks exposed is a series of layers of arenaceous shales, clays, limestones, and ferruginous nodules, following one another rapidly and conformably, and having a dip of 5° E. and 30° N. The line of dip as shown in the fall of the section is, however, much distorted, a fact which is due partly to the presence of a number of small faults, and partly to the unequal shrinkage which the shales and clays probably underwent during the processes of lithification. The following is the sequence that the strata in this pit at present exhibit, the total thickness of which is 35 feet 3½ inches. (See p. 254.)

Many of these layers, however, are not persistent even over short horizontal distances, and hence it is that no two pits in the district offer the same sequence in their sections, and even in the same pit they vary as the work of excavation proceeds. Mr. W. D. Carr[3] remarks that at Lincoln the "Marlstone Rock-bed is entirely absent," and

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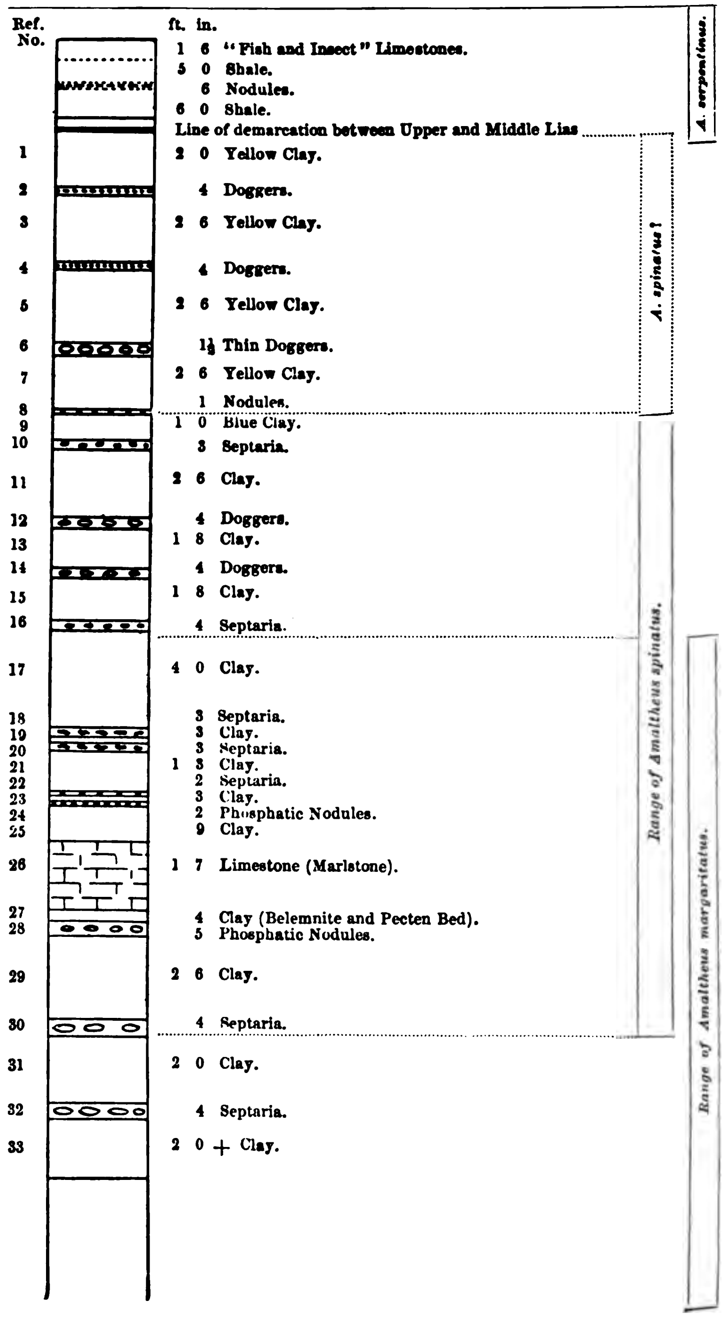
[1] Loc. cit., pp. 36–7, taf. i, figs. 5*a*–*b*; taf. ii, figs. 10*a*–*b*.

[2] Memoir of the Geological Survey, sheet 83, pp. 24 and 25.

[3] W. D. Carr, "The Lincoln Lias": GEOLOGICAL MAGAZINE, April, 1883.

SECTION OF STRATA EXPOSED IN MIDDLE LIAS AT HANDLEY'S PIT, LINCOLN.



A. serpentinus.
A. spinatus?
Range of Amaltheus spinatus.
Range of Amaltheus margaritatus.

Ref. No.	ft.	in.	
	1	6	"Fish and Insect" Limestones.
	5	0	Shale.
		6	Nodules.
	6	0	Shale.
			Line of demarcation between Upper and Middle Lias
1	2	0	Yellow Clay.
2		4	Doggers.
3	2	6	Yellow Clay.
4		4	Doggers.
5	2	6	Yellow Clay.
6		1½	Thin Doggers.
7	2	6	Yellow Clay.
8		1	Nodules.
9	1	0	Blue Clay.
10		3	Septaria.
11	2	6	Clay.
12		4	Doggers.
13	1	8	Clay.
14		4	Doggers.
15	1	8	Clay.
16		4	Septaria.
17	4	0	Clay.
18		3	Septaria.
19		3	Clay.
20		3	Septaria.
21	1	3	Clay.
22		2	Septaria.
23		3	Clay.
24		2	Phosphatic Nodules.
25		9	Clay.
26	1	7	Limestone (Marlstone).
27		4	Clay (Belemnite and Pecten Bed).
28		5	Phosphatic Nodules.
29	2	6	Clay.
30		4	Septaria.
31	2	0	Clay.
32		4	Septaria.
33	2	0 +	Clay.

notes that "its disappearance is remarkable as it is known at ›adenham, ten miles to the south, though rapidly thinning out, d it occurs also some distance north of Lincoln."

It was this impersistence that lead Mr. Carr to infer the entire sence of this bed at Lincoln. As I shall presently show, however, e Marlstone occurs both in this and in the adjoining disused pit Glaisiers. But although the sequence of the beds in the different ts varies so much, little difficulty is experienced in determining in general way the equivalence of conditions in the different localities, there are several horizons, e.g. layers 11, 17, and 18 to 30 (see ction, p. 254), that are strongly marked, and as far as I have en able to determine they are also fairly constant.

In the cutting that has recently been made on the slopes that tervene between the pit of the Lincoln Brick Company and that Handley, the top bed of the Middle Lias, which is overlain by the sement "Fish and Insect" Limestones of the Upper Lias, is well posed. This "Fish and Insect" bed consists of a stratum of soft rruginous, arenaceous, finely laminated, and very fissile limestone a yellowish colour, weathering grey. It has associated with it imbers of compact limestone nodules that are traversed with inute veins of calcite, and crowded with the remains of small rals (*Astrea*), *Belemnites*, *Ammonites annulatus*, *Discohelix aratus*, d small Gasteropods (*Turritella* and *Chemnitzia*).

The bedding planes of the limestone are crowded with the casts d shells of *Inoceramus dubius*, Sow , and also with great quantities golden-coloured particles of the shells of this mollusc that bear some cases a strong resemblance to the scales of fishes and the ings and elytra of beetles. Casts of *Astarte*, sp., *Lima*, sp., the rrowings of Annelids, and fragments of calcified and pyritized ood, are also common. The Ammonites and Gasteropods are often und filled with calc-spar.

Beneath this lies a bed of blue shaly clay that is highly pyritous d thinly laminated, and has an intercalated band of ferruginous nestone nodules. These nodules are very rotten, and having a ncentric structure they readily peel and break up. They are quite fossiliferous. The pyritous state of the shale does not appear to ve been favourable to the preservation of fossils, and notwithnding a careful search I was unable to find any traces of ganic life.

At the bottom of this cutting the tram-lines have been laid on bed of soft ferruginous sandstone that varies considerably in its trological characters. At the north end of the cutting it is compact d massive; at the south end it is very soft and friable. This ndstone readily splits into thin slabs, the bedding planes of which ow *A. spinatus*, *A. serpentinus*, *A. Thourense*, *Belemnites clavatus*, *itrupa liassica* (five inches long), and casts of *Lima*, *Pecten*, *Leda*, *rdium*, and *Nucula*.

Below this is a series of alternating beds of clays, shales, nodular ms, and limestone bands, but in none of them are the conditions ourable to the preservation of organic remains.

In Handley's Pit four phases of shale deposits are exposed within a vertical range of 15 feet; and each is separated from the other by a line of ferruginous septaria. When freshly cut, the shales are of a dark-blue colour, but on exposure they weather to a light-grey. In composition they are decidedly argillaceous, with an admixture of carbonate of lime, of mica, and of considerable quantities of iron and silica. The carbonate of lime consists for the most part of the tests of foraminifera, the most predominant of which are *Cristellaria*, *Nodosaria*, *Cytheridea*, and *Cytherella*.[1] As a rule the shales are not rich in fossils, although pyritized wood and lignite are very common. In these latter the ligneous structure is always very marked, and when fractured they readily split in the direction of the fibre.

It is not possible in a general statement to give the thickness of these shale beds, as they vary so much at different points; the thickness in the section given on p. 254 represents the beds in the centre of the pit, and is on the whole a fair average.

The septaria in beds 6, 8, and 10 are much decomposed, and like the clays in which they lie, they contain but few traces of fossils. But those in 18, 20, 22, 24, 28, and 30 offer, in these respects, marked contrasts. Externally they present much the same appearance in size and shape. They are, however, more compact, and on being fractured are found to contain a nucleus of claystone, which has imbedded in it other small nodules, and the shells of *Lima*, *Plicatula*, *Pecten*, *Ostrea*, and *Avicula*, many of which are often invested in a pyritic matrix.

The most marked feature in the section exposed in this pit is the limestone course 25. It runs right across the face of this pit and crops out again in the adjoining Glaisiers Pit. It immediately overlies the "ferruginous nodular band," to which Mr. W. H. Dalton refers when he says: "Both at Lincoln and Grantham, whilst specimens of *A. margaritatus* have been obtained beneath this ferruginous nodular band, no signs of that fossil were observed above it, so it seems to form the upward local limit of the zone or range of *A. margaritatus*."

A. margaritatus occurs both in this limestone course and in the overlying six feet of shales, clays, and septaria, so that, as far as the Handley's Pit shows, the upward limit of *A. margaritatus* is eight feet above the "nodular band."[2] This limit is represented by the band of septaria which is marked 16 in the section. The limestone bed 25 is of a markedly argillaceous character. It is very hard and compact, and varies in thickness from 1 ft. 6 in. to 2 ft. Its fracture is very irregular, and, in places, it is frequently traversed by minute veins of calcite that cut the rock in all directions, while in others it contained masses of "dog-tooth" and "nail-head" calc-spar.

Its colour varies from a dark-grey to a light-blue, but after eathering it exhibits many iron stains. In places it passes into typical ironstone rock, or is sandwiched between two thin layers iron-pyrites, both of which have imbedded in them representatives all the fossils that are to be found, either in the limestone urse or in the subjacent and superposed clays and shales. More ssils are to be obtained from these pyritic layers than from any her part of the formation.

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[1] For the determination of the Foraminifera from these shales my thanks are due to Mr. F. Chapman, F.R.M.S.

[2] My observations have been confirmed by the Rev. E. Nelson, who has also collected *A. margaritatus* from bed 16 downwards.

Foraminifera are most abundant, and a considerable part of the d is made up of the tests of *Bairdia liassica*, and oolitic grains oxide of iron of the size and appearance of millet-seed. Referring this bed, which was then very imperfectly exposed in Glaisiers it, Mr. W. D. Carr described it as a "soft ferruginous, clayey ndstone, with occasional casts of shells that do not help in dermining the horizon." I have before referred to the finding *A. margaritatus* in it, in abundance, by the Rev. E. Nelson and yself. I also obtained from it *R. tetrahedra*, which would seem at ice to determine its equivalence with the Marlstone, that has therto been supposed to have been missing in this neighbourhood.

The septaria in 22, 24, and 28 vary considerably from those in her parts of the section. They are smooth, depressed, spheroidal asses of hard claystone. Most of them contain specular iron. icipient fracture lines that extend partially throughout their mass, d that exhibit in their fractured facets layers of powdery, ferrous ide, are a common feature.

As a rule the fossils are found attached to the exterior of the dule, and are frequently filled with calcite; but *A. margaritatus* d *A. spinatus* are more frequently found within and forming the icleus of the nodule.

Another interesting characteristic of the two septarian layers 24 d 28 is the abundance of phosphatic nodules that are contained them. These nodules are smooth, polished masses of phosphates lime and alumina, and they vary in size from a small pea to a alnut. They are of all shapes—some being symmetrically elliptical, al, and circular, whilst others are most irregular in outline. In lour they are uniformly of a light chocolate colour. Sections under e microscope showed that nearly all of them have a nucleus of ganic matter; sometimes a shell fragment, but most frequently consists of the tests of Foraminifera—*Cristellaria*, *Nodosaria*, d *Lagena*.

Immediately beneath the limestone course 26 is an irregular seam light-blue shaly clay (27), of a marked micaceous and ferruginous pect. It is chiefly remarkable for the enormous numbers of elemnites (*B. clavatus*, *B. vulgaris*, and *B. longiformis*) that it ntains. In some places they are so thick that the bed is almost itirely made up of them.

The line of junction between these Belemnite shales and the limeone is also extremely prolific in molluscan remains. Shells and sts of *Astarte*, *Lima*, *Cardinia*, *Gresslya*, *Pecten*, *Nucula* occur in asses with other, though less numerous, shells of *Eucyclus*, *Eulima*, *erithium*, *Ostrea*, *Plicatula*, and *Modiola*.

From the foregoing details it will be observed that in this section *A. margaritatus* has a higher range than has hitherto been ascribed to this fossil in the Lincoln Lias; and for a vertical distance of 15 feet the zones of *A. spinatus* and *A. margaritatus* overlap (vide section layers 16 downward to 30). This, and the well-marked line of demarcation between the Upper and the Middle Lias, as well as the reappearance of the Marlstone series, mark this as one of the most interesting sections in the Lincoln District.

The following is a list of the fossils that I have collected from this pit:—

SYNOPTICAL LIST OF THE FOSSILS FOUND IN HANDLEY'S PIT (MIDDLE LIAS).

	Zone of *A. spinatus*, Layers 1 to 16.	Zone of *A. spinatus* and *A. margaritatus* (mixed), Layers 17 to 30.	Zone of *A. margaritatus*, Zone 31 to bottom.
Plesiosaurus, sp.		*	
Amaltheus margaritatus, Mont.		*	*
A. Engelhardti, D'Orb.		*	
A. solitarius, Simp.		*	
A. spinatus, Brug.	*	*	
Nautilus (4 specimens)		*	
Belemnites clavatus, Blainv.	*	*	*
B. inæqualis, Simp.		*	
B. vulgaris, Y. and B.		*	
B. longiformis, Blake	*	*	
Cerithium, sp.	*		
Eucyclus imbricatus, Sow.		*	
Eulima, sp.	*		
Dentalium elongatum, Münst.	*		
Dentalium, sp.		*	
Ostrea irregularis		*	
Ostrea, sp.	*		
Pecten æquivalvis, Sow.		*	
Pecten (several sp.)		*	
Lima pectinoides, Sow		*	*
Lima (several sp.)		*	
Plicatula liasina, Terq.		*	*
P. spinosa, Sow.		*	
Monotis cygnipes, Y. and B	*	*	
M. inæquivalvis, Sow.		*	
Gervillia, sp.		*	
Inoceramus, sp.		*	
Pinna, sp.		*	
Modiola scalprum, Sow.	*	*	
Cucullæa, sp.	*	*	
Nucula, sp.	*	*	*
Leda galathea, D'Orb.		*	
Lucina, sp.			*
Unicardium, sp.		*	
Astarte, sp.		*	
Cardinia crassiuscula, Sow.			*
Pholadomya ambigua, Sow.		*	*
Goniomya V-scripta, Sby.		*	
Gresslya intermedia, Simp.		*	*
G. donaciformis, Phill.	*	*	
Pleuromya costata, Y. and B.		*	
Ceromya, sp.	*		
Homomya, sp.		*	

	Zone of *A. spinatus*, Layers 1 to 16.	Zone of *A. spinatus* and *A. margaritatus* (mixed), Layers 17 to 30.	Zone of *A. margaritatus*, Zone 31 to bottom.
s, sp.	●		
sp.		●	
orbis)	●		
s, sp.		●	
lla tetrahedra, Sow. . .		●	
lla, sp.		●	
s.		●	
sps.		●	
s, sp.		●	
mucronata		●	
ta, D'Orb..		●	
ina, D'Orb..		●	
s, Lin.		●	
recta, D'Orb.. . . .		●	
Born.		●	
a, F. and M.		●	
a raphanus, L. . . .		●	
ria excavata, Terq. . .		●	
s incerta, D'Orb. . . .		●	
, sp.		●	

OUND AT THE BASE OF THE UPPER LIAS IMMEDIATELY ABOVE HANDLEY'S PIT.

monites serpentinus.
Thourense.
annulatus.
nnitzia, sp.

Astarte, sp.
Dentalium elongatum.
Inoceramus dubius.
Cerithium, sp.

SOME FOSSIL ENTOMOSTRACA FROM SOUTH AMERICA.

By Professor T. RUPERT JONES, F.R.S., F.G.S.

(PLATES X AND XII.)[1]

CONTENTS.

PART I.—§ i. Introduction.
§ ii. Geinitz, 1876.
§ iii. *Estheria Mangaliensis*, Jones (Geinitz).
§ iv. Stelzner; Cacheuta, 1885.
§ v. Philippi, 1887.
§ vi. *Estheria Forbesii*, Jones.
§ vii. *Estheria Aricensis*, sp. nov.
PART II.—§ viii. *Estheria Chilensis*, Philippi.
§ ix. Szajnocha, 1888.
§ x. Summary of the foregoing notes.
§ xi. *Estheria Mawsoni*, sp. nov., and var.
§ xii. Ostracoda.
§ xiii. Conclusion.

PART I.

§ I. INTRODUCTION.

are now in the British Museum (Natural History Branch) pecimens of fossil *Estheriæ* from South America, beside

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ind XI will appear in the July Number with the second part of this paper.

those described and figured in the "Monograph of Fossil *Estheriæ*" (Palæontographical Society), 1862, pp. 109–111, pl. iv, figs. 8–11.

1. There are some from the same locality as those already dealt with, namely, *Estheria Forbesii*, Jones, from Cacheuta in the province of Mendoza, Argentine Republic.

2. Others collected by David Forbes at another place, namely, Arica,[1] Department of Arequipa, in Southern Peru.

3. An interesting series from Brazil; partly described and illustrated in the GEOLOGICAL MAGAZINE for May, 1897, pp. 195–202, Pl. VIII.

From Cacheuta and Challao (both in the province of Mendoza) more or less similar specimens have been described by H. B. Geinitz and R. A. Philippi; and the latter has treated of a species, probably from the district of Lebu, Chili, like that which Dr. Forbes found at Arica. These, therefore, have to be compared. The Brazilian specimens referred to above belong to four new species, including three of *Estheriïna*, gen. nov., elsewhere described.

The close similarity that many *Estheriæ* have one to another in the shape of the carapace, the only part of the animal remaining, when fossil, for the geologist to examine, makes the determination of fossil species very difficult. The limbs and soft parts having perished, the features of the valves, such as shape and contour, the lines of growth and their interstices, are all that give the means of judging specific differences. In the more or less crushed or otherwise modified state in which the fossil carapaces often occur the difficulties are multiplied.

The sex of individuals influences the carapace; and the successional stages of growth are accompanied by differences of outline. Many such modifications and variations of form are recognizable in published works treating of these Phyllopods. For example, G. O. Sars, of Christiania, has well illustrated and explained the gradational changes, from the egg to the adult form, in *Cyclestheria Hislopi*[2] and *Estheria Packardi*.[3]

§ II. GEINITZ, 1876.

In 1876 Professor Dr. H. B. Geinitz described and figured several fossil *Estheriæ* from the Rhætic carbonaceous shales and associated dark-grey clays of Challao and elsewhere in the Mendoza province, Argentine Republic. All these specimens he referred to *Estheria Mangaliensis*, Jones: see "Beiträge zur Geologie und Palaeontologie des Argentinischen Republik," II, Palaeontologischer Theil, Abth. 2; "Ueber Rhaetische Pflanzen- und Thier-Reste in den Argentinischen Provinzen La Rioja, San Juan, und Mendoza," 1876, p. 3, pl. i, figs. 1–6.

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[1] Now held by the Chilians as an indemnity for war expenses, or taken by them in 1886.

[2] Christiania Vidensk.-Selsk. Forhandl. 1887, No. 1.

[3] Archiv Math. og Naturv. Attende Bind, Förste Hefte, June, 1896, Kristiania. In this memoir on *E. Packardi* is given the complete history of the growth of an *Estheria* and its valves.

He states that "In the Universal Exhibition at Paris in 1867, the Argentine Republic exhibited bituminous shales (Brandschiefer), containing numerous shells of an *Estheria*, together with other bituminous substances, such as 'Carbon de Piedra,' from the district of San Lorenzo, province of Mendoza. Professor Stelzner has collected specimens of a similar Brandschiefer or bituminous shale at different places in the Sierra of Mendoza, as near Challao,[1] at the Agua salada, west of the town, at the Cerro de Cacheuta, south of the same, and at the Agua de la Zorra in the Sierra de Uspallate. These shales are full of the same *Estheria*." The specimens illustrated by Dr. Geinitz, if regarded as showing their true shape, would represent more than one species, very difficult to identify with any known forms. They all seem, however, to have been more or less distorted by pressure, and to this cause, rather than to natural proportions, it appears likely that the diverse positions of the umbo, in relation to the antero-dorsal corner of the test, and the modifications of the concentric ridges, and the differences in the outlines, may possibly be due.

On careful consideration, it is evident that his fig. 4 is, of all the series, the most like *E. Mangaliensis*, Jones, and that figs. 1 and 2 may belong to the same species, but have been obliquely narrowed by pressure. Of the other three, fig. 5 is most like *E. Forbesii*, Jones, as to outline and number of ridges, but has been narrowed vertically by pressure. Figs. 3 and 6 differ from the others, and from each other, by the position of the umbo, number of ridges, and general shape. In explanation of the above remarks, the following notes are given:—

§ III. (1) ESTHERIA MANGALIENSIS, Jones.

Estheria Mangaliensis, Jones, "Monogr. Foss. *Estheriæ*": Pal. Soc. 1862, p. 78, pl. ii, figs. 16–23.

——— ——— Geinitz (*pars*), Palæontographica, Suppl., iii, Palæont. Theil ii, Abth. 2; Beiträge, etc., 1876, p. 3, pl. i, fig. 4 and figs. 1 and 2?

——— ——— Middleton, Intellect. Observer, No. xxi, October, 1862, p. 317.

——— ——— Medlicott and Blanford, "Manual Geol. India," 1879, p. 130, woodcut; 2nd edit., 1893, p. 170, woodcut.

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[1] In his "Reise durch die La Plata Staaten," etc., 2 vols., 1861, at page 277 of vol. i, H. Burmeister observed at some places "remnants of Cypridinen-Schalen, with the little Crustaceans characteristic of the Coal-formation of Europe." In his "Description physique de la République Argentine," 5 vols., 1876–8, in vol. i (1876), p. 262, Burmeister states that "on the eastern side of the mountains, towards the plain of the Pampa, is a small ravine opening out above the Bath of Challao; and in it are some black, irregularly flaking shales, like the Coal-shales; and these contain here and there traces of carbonized leaves, and on other surfaces impressions of little shells, like the valves of *Cypridina*, that remarkable Crustacean genus, belonging to the Phyllopoda, near the genus *Estheria*, and so characteristic of the Coal-beds of Europe." Burmeister here evidently alluded to the "Cypridinen-Schiefer" (*Entomis*-shales) characteristic of the Devonian (not the Carboniferous) of Europe from Russia to England.

Adult carapace-valves, broadly subovate in outline. Length 8·3, height 5·6 mm. Young forms, subtriangular or suboblong. Its resemblance to *E. Gihoni* is mentioned at p. 78, op. cit.

The original was from Mangali in Central India, probably of Rhætic age. Dr. Geinitz's specimens (see above) were from Challao and elsewhere[1] in the Mendoza province of the Argentine Republic; accompanied by *E. Forbesii* if we take Geinitz's fig. 5, pl. i (1876), to represent the latter species. Of the six figures referred by Dr. H. B. Geinitz to *E. Mangaliensis* (op cit. 1876), one, namely fig. 4, seems to represent this species, and figs. 1 and 2 may also belong to it.

	CONCENTRIC RIDGES.		MESHES FROM RIDGE TO RIDGE.	
E. Dahalacensis	14–15	. . .	6–7	
E. Gihoni	14–15	. . .	6–7	adult, but not so old as the others.
E. Mangaliensis	16–17	. . .	7–8	
E. Forbesii	22–23	. . .	17–18	

E. Forbesii (numbers imbedded in a brownish shale) was brought to England by David Forbes in 1861 from Cacheuta, in the province of Mendoza.

Professor Philippi's specimens of *E. Mendocina*, referred to further on, also came from near Cacheuta in Mendoza. It bears a close resemblance to *E. Forbesii*, and measures 11 × 8 mm.

§ IV. STELZNER; CACHEUTA, 1885.

The Cerro de Cacheuta, on the eastern slope of the Andes, 3500-4000 feet above the sea, is about twenty miles S. by W. of Mendoza city (33° S. lat.), in the Argentine Republic. Its geological structure is shown in Stelzner's map and sections (pl. iii) in his "Beiträge zur Geologie und Palaeontologie des Argentinischen Republik," I, Geologischer Theil, 1885, p. 76, etc.; in Fischer's "Palæontographica," Suppl., iii, Lieferung ii, Heft 1, "Ueber die geognostischen Verhaltnisse der Umgegend von Mendoza," etc.

This hill of Cacheuta consists mainly of gneiss and mica-schist, with a central mass of intrusive igneous rocks ("trachyte, andesite, and basalt"). On one flank of the hill strata of variegated sandstone, with clay and carbonaceous shale, lie in a broken syncline with steep sides. These beds are referred to the Rhætic series.

§ V. PHILIPPI, 1887.

In his "Die Tertiären und Quatären Versteinerungen Chiles," etc., 1887, Dr. R. A. Philippi described and gave some small figures of two kinds of *Estheria*, p. 223, pl. L, figs. 11 and 12. The little outline, fig. 11 (16 × 12½ mm.) is described as a suborbicular form, like "*Estheria Dahalacensis*" (probably by accident or error), slightly oblique, very thin, almost flat, with irregularly concentric wrinkles; one margin nearly straight, with the umbo at two-fifths of its length. Philippi named it *Estheria? Chilensis* (reproduced

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[1] Of the six specimens it is stated, at p. 16, that they came from Agua de la Zorra, Challao, Agua salada, Cerro de Cacheuta, and San Lorenzo.

l. X, Fig. 5); and stated that it came *probably* from the district ebu. This is on the sea-coast in the province Arauca, Chili, 36′ (or 37° 39′) S. lat., and is said to be on a Tertiary ation, in which are seams of lignite or coal, associated with s bearing Tertiary marine shells. Stelzner intimates that ippi's researches (1878 and 1883) prove the existence there th an Eocene and a later Tertiary formation. See also Philippi, rt. u. Quat. Verst. Chiles," 1887, p. 17.

e little sketches in fig. 12 (11 × 8 mm.) have in their general t the look of *E. Forbesii*, being subovate, with a long, straight ; and, although the curvatures of the ends do not correspond sibly having been squeezed), the specimens shown by fig. 12 oduced in Pl. XI, Fig. 2) may safely be referred to the above-ioned species. Philippi mentions that they came from Cacheuta lendoza, and named them *E.? Mendocina*. Unfortunately, he d that they are like a "*Posidonia*." Most probably by some lent "*Posidonia*" and "*E. Dahalacensis*" were erroneously laced one for the other by the author in writing his notes ese two species.

make the subject quite clear the following notes are necessary:

§ VI. (2) Estheria Forbesii, Jones.

Plate XI, Fig. 2.

idina, Burmeister, 1861, "Reise durch die La Plata Staaten," vol. i, p. 77; "Descrip. Phys.," etc., vol. i, 1876, p. 262.

eria Forbesii, Jones, "Monogr. Foss. *Estheriæ*": Pal. Soc. 1862, p. 109, pl. iv, figs. 8–11.

lendocina,[1] Philippi, "Tert. u. Quat. Verst. Chiles," etc., 1887, p. 223, pl. L, fig. 12.

legalensis (*pars*), Geinitz, "Beiträge zur Geologie und Palaeontologie des Argentinischen Republik," II, Palaeont. Theil, Abth. 2; "Ueber Rhaetische Pflanzen- und Thier-Reste in den Argentinischen Provinzen La Rioja, San Juan, und Mendoza," 1876, p. 3, pl. i, fig. 5.

is straight-backed *Estheria* is suboblong when adult ("Monogr. . *Esth.*," pl. iv, fig. 8), with about twenty-two concentric ridges; interspaces reticulate, with about seventeen meshes from ridge dge. In the young state (fig. 9, with 13 ridges; and fig. 10, only seven) the shape is subcircular or subquadrate, as in r young *Estheriæ*. The adult form (fig. 8) measures—length , height 7 mm.

. *Forbesii* much resembles several other known *Estheriæ* in ral shape and in style of ornament; but there are points of rence in all these cases. Some varieties of the Triassic *E. minuta* be alluded to: such as "Monogr.," pl. ii, fig. 9, var. *Brodieana*;

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[1] he province of Mendoza, indicated by the name *Mendocina*, formerly belonging ili, and so referred to by Philippi, was previously known as Cuyo, and part Plata. It is now described by geographers as belonging to the Argentine blic, the mutual boundary having been settled by a treaty in 1881. The limit along the crest of the Andes down to the Magellan Straits.

also fig. 16, *E. Mangaliensis*; and *E. minuta* var. *latitexta*, GEOL. MAG. 1890, Pl. XII, Fig. 8. These approach one another in outline and ornament, but appreciable differences are readily discernible.

Among recent species, *Estheria Dahalacensis*, Straus-Durckheim, and *E. Gikoni*, Baird, are also straight-backed forms, with reticulate ornaments between the ridges, but there are differences in outline and surface.

§ VII. (3) ESTHERIA ARICENSIS, sp. nov.

PLATE X, Figs. 1–3.

This species is based on some specimens which the late David Forbes, F.R.S., brought to England, in 1861, from Arica in Southern Peru (now held by the Chilians), in 18° 25′ S. lat., 70° 15′ W. long. These fossils have been placed in the British Museum (Nat. Hist. Branch) since *Estheria Forbesii* was described by me in 1862. They are illustrated by Figs. 1–3, and are obliquely subcircular (not unlike some forms of *Posidonomya*), with the longest diameter at an angle of about 60° to the hinge-line. This latter is usually about half the length of the valve, but sometimes two-thirds. The umbo is in the anterior third of the cardinal margin, and rather prominent above the hinge-line.

The concentric ridges are numerous (16 or more), mostly large and coarse, but somewhat obscured by pressure and the granular sandy condition of the matrix. In one large hollow mould (unfortunately imperfect, Fig. 3), vertical barrolets, or small transverse ridgelets, are visible in the broader interspaces.

These specimens from Arica measure—

Fig. 2, length 9·4 mm., height 8·0 mm.
Fig. 1, length 13·63 mm., height 9·45 mm.
Fig. 3 (imperfect), length 17·0 mm., height 15·02 mm.

From a fractured internal cast of a valve, the thickness of the closed carapace of a large individual may have been about 4 mm.

They occur on the bed-planes of a hard, black, irregularly fissile, sandy shale, which has weathered brown inwards to some distance from the surface. According to David Forbes's label they came from "Bed F, Morro de Arica." The hill near the town rises to about 500 feet above the sea-level. He was there in 1857, and on May 27, 1861.

In the Quart. Journ. Geol. Soc., vol. xvii, 1861, pp. 35–6, he described the section as exhibiting a succession of interstratified shales and porphyries, to which, although regarded as Carboniferous by D'Orbigny, D. Forbes hesitated to assign any definite age, for want of evidence.

These *Estheriæ* from Arica differ from Philippi's *E. Chilensis*[1] by the greater obliquity of the valves and more definite hinge-line. Philippi's published sketch, op. cit., 1887, pl. L, fig. 11, gives, however, poor data for a decision. (See Pl. X, Figs. 4 and 5.)

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[1] 1887; see above, p. 262.

The obliquity of these suborbicular valves (about 60°) approximates to that of *Cyclestheria*, as defined by G. O. Sars[1]; but the latter is much more nearly circular in outline (Fig. 6).

The more protuberant umbo, further from the anterior corner, and the more distinctly level straightness of the hinge-line behind it, are distinctive characteristics, as well as the somewhat more prolate antero-dorsal region of the valve in front of the umbo.

(*To be concluded in our next Number.*)

NOTICES OF MEMOIRS.

I.—On the Distribution of Marine Mammals.[2] By P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Zool. Soc.

(Read before the Zoological Society, March 16, 1897.

I. *Introductory Remarks.*—Most of the recent writers on Geographical Distribution have confined their attention to terrestrial mammals, or at any rate have but casually alluded to the marine groups of that class. On the present occasion I wish to call your attention to some of the principal facts connected with the distribution over the world's surface of the marine or aquatic members of the Class of Mammals.

Aquatic mammals, which pass their lives entirely, or, for the greater part, in the water, are, of course, subject to very different laws of distribution from those of the terrestrial forms. As regards aquatic mammals, land is of course an impassable barrier to their extension, and, subject to restrictions in certain cases, water offers them a free passage. Just the opposite is the case with the terrestrial mammals, to which in most cases land offers a free passage, while seas and rivers restrain the extension of their ranges.

The groups of aquatic mammals that are represented on the earth's surface at the present time are three in number, viz.: (1) the suborder of the Carnivora, containing the Seals and their allies, generally called the Pinnipedia, which are semi-aquatic; (2) the Sirenia, which are mainly aquatic; and (3) the Cetacea, which never leave the water, and are wholly aquatic. We will consider briefly the principal representatives of these three groups, following nearly the arrangement of them employed in Flower and Lydekker's "Mammals, living and extinct."

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[1] Christiania Vidensk.-Selsk. Forhandl. 1887, No. 1, pl. i, figs. 1–3. Dr. Baird gave a rather more symmetrical form to this subcircular species (Proc. Zool. Soc. 1859, p. 232; and 1860, p. 188, pl. lxiii, fig. 1), triangular on the dorsal and rounded on the ventral margin. His figure, if placed with the hinge-line horizontal, shows a subcentral umbo, with the hinge-line almost level behind it, and equal to half of the transverse diameter of the valve. There is a rapid slope in front, meeting the anterior part of the more than semicircular free margin.

[2] For the Land-Provinces proposed by the author for the Geographical Distribution of Birds, see Dr. P. L. Sclater's paper in Journ. Proc. Linn. Soc. (Zoology) 1858, vol. ii, pp. 130–45; also Rep. Brit. Assoc. 1860, Trans. Sec., pp. 121, 122; H. Woodward, Geol. Mag. 1885, Decade III, Vol. II, p. 315, and Proc. Geol. Assoc. 1886, vol. ix, No. 5, p. 366.

II. *Distribution of Pinnipeds.*—The Pinnipeds, which I will take first, comprise three distinct families—the Otariidæ, the Trichechidæ, and the Phocidæ. Beginning with the Otariidæ or Eared Seals, commonly known as Sea-lions and Sea-bears, we find the greater number of the species confined to the South Polar Ocean, where they pass most of their time at sea, but, as is well known, resort to the land at certain seasons for breeding purposes. In the Atlantic Ocean, so far as I know, the Eared Seals have never been ascertained to occur further north than the estuary of the La Plata on the American coast, and the vicinity of the Cape on the African coast. But in the Pacific, on the contrary, three distinct species of *Otaria* are found all over the Arctic portion of that ocean, and there are well-founded traditions of Eared Seals having been formerly met with in the Galapagos, while they still occur on the coast of Peru and Chili. I think, therefore, we may assume that *Otaria* was originally an Antarctic form, but has travelled northwards along the West American coast and is now firmly established in the North Pacific. In a parallel way in the class of birds, the Albatrosses (*Diomedea*), which are essentially a group of the Antarctic seas, are represented by three distinct species in the North Pacific.

The second family of the marine Carnivora, on the other hand, the Walruses (Trichechidæ), are entirely Arctic in their distribution; one species (*Trichechus rosmarus*) being peculiar to the North Atlantic, while a second nearly allied species (*T. obesus*) takes its place in the Northern Pacific.

The third family of Pinnipeds is more numerous and varied, both in genera and species, than the two preceding, and has a more extended range. The Seals (Phocidæ), embracing about nine different generic forms, are most numerous in the Arctic and Antarctic seas, but are also feebly represented in some intermediate localities. Beginning with the North Atlantic, we find several species of *Phoca* inhabiting various parts of this area, and the Grey Seal (*Halichœrus*) and the Bladder-Seal (*Cystophora*) exclusively confined to it. In the North Pacific all the four true Seals belong to the genus *Phoca*, and three of them are identical with the North Atlantic species, but when we descend as far south as the Gulf of California on the American coast we meet with a species of Sea-elephant (*Macrorhinus*) which, like *Otaria*, has no doubt penetrated up here thus far from its ancestral abode in the Antarctic Ocean.

Returning to the Central Atlantic, we find two species of Seals inhabiting these waters, both belonging to the same genus *Monachus*. One of these (*M. albiventer*) inhabits the Mediterranean and the adjoining coasts of the Atlantic, while the other (*M. tropicalis*) is in these days restricted to some of the smaller and less known islands of the West Indies.

The Phocidæ of the Antarctic Ocean all belong to genera distinct from the Arctic forms and more nearly allied to *Monachus*, the Seal of the Mid-Atlantic. They are of four species belonging to as many genera: *Ogmorhinus*, *Lobodon*, *Leptonychotes*, and *Ommatophoca*. Besides these the Sea-elephant of the whalers (*Macrorhinus*) is essentially an Antarctic form, though now nearly extinct there, after long persecution by man. But, as already noted, it extends, or has in former days extended, far up the West coast of America, and is still occasionally found on Santa Barbara Island on the coast of California.

III. *Distribution of Sirenians.*—Only two forms of Sirenians are at the present time existing on the earth's surface—the Manatee (*Manatus*) and Dugong (*Halicore*) — each representing a distinct family of the order. The Manatee is an inhabitant of the coasts and estuaries of both sides of the middle Atlantic Ocean — one species (*Manatus Senegalensis*) occurring on the African shores, and another (*M. Americanus*) on the South American coast and in the Antilles. A third species (*M. inunguis*), so far as we know at present, is found only in fresh water high up the Amazons.

The Dugong (*Halicore*) is distributed from East Africa, along the shores of the Indian Ocean and its islands, to North Australia. Three species of this genus have been established — *Halicore tabernaculi* from the Red Sea, *H. dugong* from the Indian Ocean, and *H. Australis* from Australia; but it is doubtful how far these forms are actually distinguishable.

Beside *Manatus* and *Halicore*, a third quite distinct form of Sirenian was formerly an inhabitant of the North Pacific. This was Steller's Sea-cow (*Rhytina Stelleri*), by far the largest animal of the group, which was exterminated by human agency about 1768. Fortunately recent researches in Behring's Island have been successful in supplying specimens of its skeleton for our principal Museums, and Steller, its discoverer, left to posterity a good account of its habits and anatomy.

IV. *Distribution of Cetaceans.*—Adopting the recognized division of the Cetaceans into two suborders, Mystacoceti and Odontoceti, according as to whether their mouths are furnished with baleen ("whalebone") or teeth, we will first consider the True or Whalebone Whales, which consist of a single family, Balænidæ, usually divided into five genera: *Balæna, Neobalæna, Rhachianectes, Megaptera,* and *Balænoptera.* Of these, *Balæna, Megaptera,* and *Balænoptera* are almost cosmopolitan—species of them, whether distinct or not is at present more or less uncertain, being met with in nearly every part of the ocean. But *Rhachianectes* has as yet been ascertained to occur only in the Northern Pacific, and *Neobalæna* in the South Polar Ocean, so that we have in these cases two well-marked local types to deal with.

The Toothed Wales (Odontoceti) are more diversified than the preceding group, and are usually held to embrace at least four existing families besides several extinct forms. The first family, containing the Physeteridæ or Sperm-Whales, consists of at least six genera (*Physeter, Cogia, Hyperoodon, Ziphius, Mesoplodon,* and *Berardius*). *Physeter* and *Cogia* are inhabitants of the whole oceanic area between the tropics, extending in certain localities some way beyond them. *Hyperoodon* is confined to the North Atlantic. *Ziphius* has an extensive range, and has been found in nearly every part of the ocean. ***Mesoplodon*** is also widely distributed, but is apparently more abundant in the Southern Hemisphere. ***Berardius***, however, so far as we know at present, is restricted to the South Polar Ocean.

The third family of Toothed Whales contains only the Platanistidæ, or Fresh-water Dolphins, which, although, in some cases, at the present day entirely fluviatile, must probably have descended from oceanic forms. The three known genera are ***Platanista*** of the Ganges and Indus, ***Inia*** of the river Amazons, and ***Pontoporia*** of the river La Plata; the last form making a connecting link between the two preceding genera and the marine Dolphins.

The fourth family of Toothed Whales, containing the Dolphins, Delphinidæ, is very numerous in species and embraces at least fifteen or sixteen genera. But in spite of the efforts of Mr. True, who has recently given us an excellent summary of our present knowledge of them,[1] both the genera and species of Delphinidæ are still so imperfectly understood that I cannot say much about their geographical distribution. Most of the forms appear to be very widely distributed, but it may be said generally that Dolphins are most abundant in the intertropical seas and less plentiful both to the north and south of them.

There are, however, two forms that are exclusively inhabitants of the North Atlantic. These are the very remarkable Narwhal (*Monodon*), in which the male is furnished with a single enormous horn-like tusk, and the Beluga or White-Whale (*Delphinapterus*), closely allied to the Narwhal in many points of its general structure. These may be looked upon as quite isolated forms characteristic of the Arctic portion of the Atlantic, but not known in the Pacific.

V. *Division of the Marine Area of the Globe into Sea-regions.*—From what has been already said, it will be evident that, although many of the marine mammals have a wide distribution, others are very definitely localized; and a study of the latter will, I think, enable us to divide the oceanic portion of the globe into six Sea-regions, corresponding to a certain extent with the six Land-regions[2] into which I proposed to separate the terrestrial portion of the globe in 1874, and which were subsequently adopted by Mr. Wallace in his standard work on the Geographical Distribution of Animals. I propose to call these Sea-regions—

(1) The North Atlantic Sea-region or Arctatlantis (*ἄρκτος* and *'Ατλαντίς*=the daughter of Atlas), consisting of the northern portion of the Atlantic down to about 40° N. lat.

(2) The Mid-Atlantic Sea-region or Mesatlantis (*μέσος* and *'Ατλαντίς*), consisting of the middle portion of the Atlantic down to about the Tropic of Capricorn.

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[1] See "A Review of the family Delphinidæ," by Frederick W. True: Bull. U.S. Nat. Mus., No. 36, Washington, U.S., 1889.

[2] Presidential Address, Sect. Biology, Brit. Assoc. 1875 (Bristol); and Proc. Roy. Inst., vol. viii, pp. 511-13 (1878).

(3) The Indian Sea-region or Indopelagia (Ἰνδὸς and πέλαγος), containing the Indian Ocean down to about the same degree of S. lat., and extending from the coast of Africa on the west to Australia and the great Oriental islands on the east.

(4) The North Pacific Sea-region or Arctirenia (ἄρκτος and εἰρήνη =*pax*), containing the northern portion of the Pacific Ocean down to about the Tropic of Cancer.

(5) The Mid-Pacific Sea-region or Mesirenia (μέσος and εἰρήνη), containing the intertropical portion of the Pacific Ocean; and finally,

(6) The Southern Sea-region or Notopelagia (νότος and πέλαγος), containing the whole of the South Polar Ocean all round the globe south of the above-mentioned limits.

We will now proceed to consider shortly the characteristic Mammals of these six Sea-regions.

VI. *The North Atlantic Sea-region, or Arctatlantis.*—Amongst the Pinnipeds two well-marked generic forms, the Grey Seal (*Halichœrus*) and the Bladder-Seal (*Cystophora*), are exclusively confined to Arctatlantis. The True Seals (*Phoca*) and the Walrus (*Trichechus*) are found in this region and in Arctirenia; and of the former genus three species (*P. vitulina*, *P. Grœnlandica*, and *P. barbata*) are actually common to both these Sea-regions, while the Walruses (*Trichechus rosmarus* and *T. obesus*) of the two Sea-regions are perhaps somewhat doubtfully distinguishable. It may be easily understood how this has come to pass, because the Seals and Walrus may in the course of time, during unusually mild summers, have extended themselves along the north coast of the American continent into the Northern Pacific. But Arctirenia, as we shall presently show, is markedly distinguishable from Arctatlantis by the presence of Eared Seals (*Otaria*), which are utterly unknown in the whole of the Atlantic area. *Otaria* is, in fact, as regards Arctatlantis what I have called on previous occasions (see P.Z.S. 1882, p. 311) a "lipotype" of Arctatlantis, but what I now propose to designate a "lipomorph."[1]

The Sirenians are entirely absent from the North Atlantic and constitute another lipomorph of that area.

Coming to the Whales, we find the Mystacoceti well represented in the North Atlantic by *Balæna*, *Megaptera*, and *Balænoptera*, but of these the two latter are almost universally distributed over the ocean, and *Balæna* recurs again in the North Pacific as well as in more southern latitudes, so that there is no genus of Whalebone Whales peculiar to Arctatlantis, although the great *Balæna mysticetus* has never been found elsewhere.

Proceeding to the Odontoceti, the case is different. Amongst the

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[1] On former occasions I have used the term "lipotype" for a natural group which characterizes a particular locality by its *absence*. It would, however, perhaps be better to change the term to "lipomorph," because the type and its compounds have been generally employed in reference to the particular specimens of a species upon which original descriptions are based (cf. Thomas, P.Z.S. 1893, p. 241). In the same way a natural group which characterizes a particular country may be called a "topomorph" (τόπος, *locus*, and μορφή, *forma*). Thus in Africa *Giraffa* and *Phacochœrus* would be "topomorphs," and *Cervus* and *Ursus* would be "lipomorphs."

Physeteridæ, *Hyperoodon* is confined to Arctatlantis, and, as already explained, two very well-marked types of the Delphinidæ, *Delphinapterus* and *Monodon*, are likewise exclusively denizens of the North Atlantic ocean. Arctatlantis, therefore, may be said to be well characterized by the possession of at least five genera of Marine Mammals not found elsewhere, viz. *Halichœrus*, *Cystophora*, *Hyperoodon*, *Delphinapterus*, and *Monodon*.

VII. *The Middle Atlantic Sea-region, or Mesatlantis.*—Mesatlantis has certainly not so many forms of Marine Mammals confined to its area as Arctatlantis, but there seem to be good grounds for its separation. As we descend towards the tropics the true Seals (Phocinæ), which are constituted to live in colder water, gradually fall off in number, and in Mesatlantis are no longer met with. But in their place we find the genus *Monachus* or Monk-Seal restricted to Mesatlantis, one species (*M. albiventer*) occurring in the Mediterranean and on the North African coast, and a second (*M. tropicalis*) being found in the West Indies. Mesatlantis is likewise the true home of the well-marked Sirenian genus *Manatus*, one species of which (*M. Americanus*) frequents the coast of America and another (*M. Senegalensis*) that of Africa.

As regards the Cetaceans we are not able to say that Mesatlantis, although well furnished with many generic types of this Order, has anyone peculiar to it. We must therefore rest content with assigning two genera of Marine Mammals, *Monachus* and *Manatus*, as characteristic forms or topomorphs of the Sea-Mammal life of Mesatlantis.

VIII. *The Indian Sea-region, or Indopelagia.* — The Marine Carnivora, so far as we know, are entirely foreign to Indopelagia, but the Sirenians are well represented by the Dugong (*Halicore*), which pervades all its northern coasts from North Australia to India and the Red Sea and down the African coast to Lamu.[1] Whether the species of *Halicore* found at different points within this area are the same or different, is still a matter of discussion, but there can be no doubt that *Halicore* is an exclusive inhabitant of Indopelagia. As regards the Whales of Indopelagia, we know that *Physeter*, *Cogia*, and *Ziphius*, and numerous forms of Delphinidæ occur there. but I am not aware of any Cetacean that is entirely restricted to this Sea-region.

IX. *The North Pacific Sea-region, or Arctirenia.*—As was pointed out when speaking of Arctatlantis, Arctirenia has one genus of Phocidæ (*Phoca*) in common with the North Atlantic, and three of the species of this genus appear to be actually identical in these two Sea-regions, whilst a fourth *Phoca* (*P. fasciata*) is only found in the North Pacific. The Walrus (*Trichechus*) is again a form of Marine Mammals common to both the great northern Sea-regions. But the feature of Pinnipedian life that absolutely distinguishes Arctirenia from Arctatlantis is the presence in the former of three (if not four) well-marked species of the Eared Seals (Otariidæ), which are absolutely unknown in the vast extent of the Atlantic down at least to 30° S. lat.

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[1] A fine specimen of the Dugong from Lamu (on the east coast of Africa, lat. 2° 50′ S.), obtained by Mr. J. C. Haggard in 1885, is in the British Museum.

Arctirenia has unfortunately lost its Sirenian, Steller's Sea-cow (***Rhytina Stelleri***), the largest and finest modern representative of this formerly prevalent group, which since the days of the Pleistocene has greatly diminished in numbers, but I think we may still treat ***Rhytina*** as one of the characteristic forms of the Arctirenian Sea-region. The North Pacific is also even at the present day the sole possessor of a remarkable genus of Whalebone Whales which combines the long head and elongate form of ***Balænoptera*** with the smooth skin of the throat and absence of the dorsal fin of ***Balæna***.[1] This is the Grey Whale, ***Rhachianectes glaucus*** of Cope, which, in these days, is confined to the North Pacific, and does not range farther south that the 20th parallel in that ocean. At the same time it should be stated that indications have been discovered that a nearly allied form existed in the Atlantic in previous geological ages, though this is by no means certain. Besides ***Rhachianectes***, ***Balæna***, ***Megaptera***, and ***Balænoptera*** are all represented in the North Pacific, and also many species of Delphinidæ, of which little is at present known. But ***Rhytina*** and ***Rhachianectes*** are the only genera of Marine Mammals absolutely confined to Arctirenia.

X. ***The Middle Pacific Sea-region, or Mesirenia.***—The Eared Seals, ***Otaria***, must have necessarily passed through Mesirenia in their passage from south to north, though the only record of their recent presence in the central part of the Pacific is, so far as I know, the report that they were formerly found in the Galapagos. It should be stated, however, that Tschudi records the occurrence of two species of ***Otaria*** on the islands of the coast of Peru, and that in 1802 Humboldt met with an Eared Seal on the Island of San Lorenzo, in the Bay of Callao, which is only some 12° south of the Equator.

Like ***Otaria***, the Sea-elephant (***Macrorhinus***) has apparently in former ages travelled up the South American shores and established itself as far north on the coast of California at about 34° N. lat. The Californian Sea-elephant has been discriminated by Gill as a distinct species (***Macrorhinus angustirostris***), but its differences from the southern form (***M. leoninus***) seem to be but trifling.

As regards the Cetaceans of Mesirenia, our information is at present very imperfect, and I have little to say except that species of ***Megaptera***, ***Balænoptera***, ***Physeter***, ***Cogia***, and ***Ziphius*** certainly occur there, besides many representatives of the widely-spread Delphinidæ.

XI. ***The Southern Polar Sea-region, or Notopelagia.***—The wide ocean which surrounds the Southern Pole on every side, and extends up to 40° S. lat., seems to present, as regards its marine mammals, a nearly homogeneous fauna, which we will now briefly consider. In the first place it contains representatives of four genera of true Phocidæ—***Ogmorhinus***, ***Lobodon***, ***Leptonychotes***,[2] and ***Ommatophoca***, which are peculiar to the southern seas, and are quite distinct from all their northern representatives in the Arctic Ocean. The Sea-elephant, *Macrorhinus*, is also a denizen of Notopelagia, though, as we have already seen, it has wandered north along the South American coast far into Mesirenia.

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[1] Flower and Lydekker, "Mammals," p. 241.

[2] This generic term, established by Gill in 1872, seems to take precedence of *Pœcilophoca*, proposed by Flower and Lydekker for the same type (*L. Weddelli*) in 1891. Cf. Allen, "North American Pinnipeds," p. 418.

Like *Macrorhinus*, *Otaria* also, containing the group of Eared Seals, appears to have been originally an Antarctic group, and the greater number of its species, although nowadays very much reduced in numbers, are still found in the Southern Ocean. But the *Otariæ* have travelled still further north than *Macrorhinus*, and three, if not four, species, as already stated, are in these days well-established inhabitants of Arctirenia.

The Sirenians are absent from Notopelagia, but Cetaceans of every kind are abundant. Besides one or more representatives of the true Whalebone Whale (*Balæna*), Notopelagia has a smaller representative of the group (*Neobalæna*) entirely restricted to its area. It has also representatives of *Megaptera* and *Balænoptera*, though it is doubtful how far they are even specifically distinct from some of their northern representatives.

Among the Toothed Whales (Odontoceti) we find a large Ziphioid form, *Berardius*, restricted to the Notopelagian area, while *Ziphius* and *Mesoplodon* also occur there. The Dolphins (Delphinidæ) are likewise numerous, and present some distinct species, but not, so far as our present knowledge extends, any generic forms that do not occur elsewhere.

But Notopelagia is sufficiently distinguished from all the five more northern sea-regions by possessing four genera of Seals and two of Cetaceans entirely restricted to its area.

XII. *Conclusions.*—It has therefore, I think, been shown that for the Geography of Marine Mammals, the Ocean may be most conveniently divided into six Sea-regions, as follows:—

I. Regio Arctatlantica, characterized by its Seals (Phocinæ), of which two genera, *Halichœrus* and *Cystophora*, are peculiar, whilst *Phoca* is common to it and Arctirenia; by the absence of Sirenians; and by the possession of three peculiar genera of Cetaceans (*Hyperoodon*, *Delphinapterus*, and *Monodon*).

II. Regio Mesatlantica, sole possessor of the Monk-seal, *Monachus*, amongst the Pinnipeds, and of the Sirenian genus *Manatus*.

III. Regio Indopelagica, characterized by the presence of the Sirenian *Halicore* and by the absence of Pinnipeds.

IV. Regio Arctirenica, with *Phocá* like the Regio Arctatlantica, but having *Otaria* also; the home of the (now extinct) Sirenian *Rhytina* and of the endemic Cetacean *Rhachianectes*.

V. Regio Mesirenica, without true Seals (Phocinæ), but having *Otariæ* and *Macrorhinus* from the South; no Sirenian known.

VI. Regio Notopelagica, characterized by four endemic genera of Phocidæ, and by the presence of many *Otariæ*; without Sirenians, but with two endemic forms of Cetaceans (*Neobalæna* and *Berardius*).

In conclusion, I will call attention to some of the more remarkable points in the general distribution of the marine Mammals, and to their apparent significance.

In the first place, it is evident that the Pacific has much more in common with the Notopelagian region than the Atlantic. *Otaria* and *Macrorhinus*, quite unknown in the Atlantic, extend themselves to the northern extremity of the Pacific, the former pervading that ocean up to Behring's Straits, and the latter reaching to the Californian coast. It follows that in former ages there must have been some barrier in the Atlantic which did not exist in the Pacific to stop their progress northwards. The only barrier I can imagine that would have effected this must have been a land uniting South America and Africa, across which they could not travel. Adopting this hypothesis, we have at the same time an explanation of the presence of the Manatee on both the American and African coasts. The Manatee could hardly live to cross the Atlantic. It is only found close to the coast, where it browses on seaweeds and other vegetable food in shallow water. How did it travel from America to Africa (or *vice versa*), unless there were a continuous shore-line between them? The same may be said of the Monk-seal (*Monachus*), of which one species lives in the Mediterranean and on the African coast and islands, and another in the West Indies. We can hardly believe that these creatures could easily traverse the whole Atlantic.

TOPOMORPHS OF THE SEA-REGIONS.

I. ARCTATLANTIS.

Halichœrus.
Cystophora.

—

Hyperoodon.
Delphinapterus.
Monodon.

II. MESATLANTIS.

Monachus.

—

Manatus.

—

Inia.
Pontoporia.

III. INDOPELAGIA.

Halicore.

—

Plantanista.

IV. ARCTIRENIA.

Otaria.

—

Rhytina (extinct).
Rhachianectes.

V. MESIRENIA.

Otaria.
Macrorhinus.

VI. NOTOPELAGIA.

Ogmorhinus.
Lobodon.
Leptonychotes.
Ommatophoca.
Otaria.

—

Neobalæna.
Berardius.

The hypothesis of a former barrier of land between Africa and America, which we know is supported by other facts of distribution,[1] would alone explain the difficulty.

On the other hand, in the Pacific we find no such break between the north and south. The aquatic Mammals of Notopelagia have evidently had free access to the whole of the Pacific for a long period, and have well availed themselves of this facility.

Again, while the great Southern Ocean exhibits a considerable uniformity of marine mammalian life, we see the Northern waters divided into two distinctly recognizable regions by the interposed masses of land. All these facts, with the one exception of the supposed Atlantic barrier, would tend in favour of the now generally accepted doctrine that the principal masses of land and water are not of modern origin, but have existed mainly in their present shapes throughout all ages.

II.—Reconhecimento Geologico dos Territorios Portuguezes, comprehendidos entre Lourenço Marques e o Rio Zambeze. Por Alfredo A. Freire de Andrade. Dissertação para o concurso da 7ª Cadeira da Escola Polytechnica. (Lisboa: Imprensa Nacional, 1894.)

A Geological Reconnaissance of the Portuguese Territories between Lorenzo Marques and the Zambesi River. By A. A. Freire de Andrade. Competitive dissertation for the seventh Chair in the Polytechnic School. 8vo; pp. 184, with a geological sketch-map. (Lisbon, 1894.)

THIS memoir contains an instructive description of the main geographical and geological features of that part of the Portuguese Province of Mozambique which lies south of the Zambesi River. Apart from its natural features, the region is of considerable interest at the present time, from its position between the Transvaal and the British South African Company's Territories on the one hand, and the sea on the other. In most English maps the country is divided into the districts of Gaza, Sofala, Manica, Sena, and Tete, but only three divisions are given in this paper, namely, the districts of Lorenzo Marques and of Inhambane on the south, and the Territories of the Mozambique and Zambesi Companies on the north. The Lorenzo Marques district consists almost exclusively of low, flat, or slightly undulating areas, bounded on the west by the porphyritic mountains of the Limbombos range, which run northwards from the Natal boundary. The range is traversed by numerous rivers, the most important being the Incomati, the Elephant, and the Limpopo. The Inhambane district is likewise a nearly flat, sandy plain of an average elevation of 300 mètres, which extends between the Limpopo and the Save River. Near the coast, the level of the country abruptly falls towards the sea. Many of the rivers and the lagoons of this district are largely charged with saline materials.

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[1] Cf. Wallace, "Geogr. Distrib.," vol. i, p. 156.

North of the Save River, in the Mozambique and Zambesi Companies' territories, the aspect of the country entirely changes: instead of sandy plains there is a succession of undulations of gradually increasing elevation, which beyond the Morungueze reach to the summit of the plateau, at levels of 1000 to 1200 m. Beyond the Lusiti River, running from south to north, is the wall-like range of the Chimanimani Mountains, the summits of which are 2000 m. above the sea. The principal rivers of this northern district are the Zambesi, Pungue, Revue, Lusiti, Busi, Mossurize. and the Save. A large portion of this area consists of gneiss and granite, which extend to near the coast and then disappear beneath modern alluvium. The author distinguishes (1) granitoid gneiss passing into granite, (2) gneiss with intercalated beds of pyroxene and with garnets and amphibolites, and (3) mica schists and chloritic schists.

In the country between Lorenzo Marques and the Zambesi there is a close connection between the altitude and the geological structure, so that it is possible to divide it into three principal zones. The lowest or coast zone, reaching from sea-level to 300 m., consists for the most part of Tertiary sediments, modern alluvial deposits, and sand-dunes. A large part of the southern districts of Lorenzo Marques (except the Limbombos Mountains) and Inhambane, and a small part of the Companies' territories, are included in this zone. The second or middle zone, from 300 to 600 m., includes the Limbombos and a large part of the northern territory, and the predominant rocks are gneiss and the more recent crystalline rocks, such as porphyry, porphyrites, and melaphyres. The third or high zone includes the eastern slopes of the high plateau and adjacent areas, with elevations between 600 and 2400 m. The rocks of this zone are principally schists, with a great variety of ancient crystallines, such as granites, granulites, diorites, diabases, gabbros, etc.

The gneiss areas are first seen in the latitude of the Mossurize River, and from here they continue northwards without interruption, forming nearly the whole of the hydrographic basin of the Busi River, except in one or two restricted localities where they are covered by Palæozoic sedimentary strata, which are traversed by granites and other eruptive rocks.

The more ancient sedimentary rocks of the country resemble those of other adjacent parts of South Africa in the absence of fossils; and as a consequence considerable doubt exists regarding their geological age. The author refers to the Silurian or Devonian a thick series of argillaceous and siliceous schists and quartzites, which are developed more particularly along the eastern declivity of the high plateau between the Save and the Zambesi, and in the Chimanimani Mountains exhibit a proximate thickness of 1000 m. They have been much disturbed and compressed, and in places they are traversed by diabases and granulites. No fossils have as yet been found in them, and their age is conjectured from their occurrence anterior to rocks considered to be Carboniferous.

Shales, sandstones, and grits, with beds of coal of Carboniferous age, occur along the left bank of the Zambesi, in the Tete basin, and in the area between it and the Rovugo river. The flora of these beds has been studied by Zeiller: it includes species of *Pecopteris*, *Allipteridium*, *Alethopteris*, *Annularia*, *Sphenophyllum*, *Cordaites*, and *Calamodendron*, which are considered to indicate the horizon of the Upper Carboniferous in Europe. Some of the bands of coal are of considerable thickness, but the quality is inferior, and owing to their distance from the coast they cannot be worked economically.

To the Karoo Formation the author attributes the conglomerates of Lorenzo Marques which extend along the east face of the Limbombos range nearly to the frontiers of the Transvaal. They consist mainly of stones and boulders of quartzite, and in places also rolled pebbles of amethyst, opal, etc., probably derived from beds of amygdaloidal porphyry. No fossils are known from these conglomerates, and all that can be positively said about them is that they are later than the Carboniferous and Pre-Jurassic, and contemporaneous with the eruptive period which continued from the Carboniferous to the Triassic.

The rocks which are found next above the Karoo series are limestones containing Nummulites, which occur near the base of the slopes of the Chimanimani Mountains, having a very slight easterly dip. They are hard, compact, white or yellow rocks, mainly composed of remains of Nummulites and other Foraminifera, with some moulds of Gasteropods. The Nummulites are small and flattened; two species, *N. Biarritzensis* and *N. Beaumonti*, can be recognized. These prove the Eocene age of the beds.

Of probably Miocene age are beds of marl overlain by compact white limestones, which occur near Goruja and the junction of the rivers Revue and Busi. The marls contain *Trochus patulus* (a Miocene species), *Ostræa crassissima*, and fragmentary shells of *Turritella* and *Cardita*.

It is not certain that Pliocene beds are represented south of the Zambesi, but the siliceous sands, which cover so large a portion of the districts of Lorenzo Marques and Inhambane, may be of this period. In some places they reach a thickness of 50 m. In some calcareous beds, which pass up into the sands, there have been found impressions of *Tapes*, *Cerithium*, and *Tellina* with a very characteristic Pliocene aspect, which supports the view that the sands may be Pliocene.

Of comparatively recent deposits may be noticed extensive areas of alluvium near the mouths of the large rivers, and the sand-dunes along the coast. The auriferous sands in the river beds within the Portuguese territory, which have been worked in many places, are too poor to yield a profit, and no other metalliferous deposits of any importance are known.

In the concluding chapter the author gives detailed descriptions of microscopic sections of the crystalline rocks from various localities.

G. J. H.

REVIEWS.

I.—THE DIPLOGRAPTIDÆ AND HETEROPRIONIDÆ OF THE SCANIAN *Rastrites* BEDS. By SV. LEONH. TÖRNQUIST. Trans. Roy. Phys. Soc. Lund, New Ser., vol. viii, 1897.

THIS short monograph by Dr. Törnquist forms a welcome addition to our knowledge of the later Diplograptidæ. In his Introduction, he remarks that he has dealt only with well-preserved specimens, rightly laying stress on the confusion created by the indiscriminate determination of imperfect forms.

In the "*Rastrites* Beds" the author includes the equivalents of our Lower and Upper Birkhill Shales, and the lower beds of the Gala-Tarannon Group.

As regards the subdivision into zones, the classification is that adopted by Tullberg in his "Skånes Graptoliter," except where recent work has necessitated a slight modification.

The following life-zones have been detected:—

1. Zone of *Diplograptus acuminatus*, Nich. (at base).
2. Zone of *Monograptus cyphus*, Lapw.
3. Zone of *Monograptus triangulatus*, Harkn. (= Lower part of Scottish zone of *M. gregarius*, Lapw.)
4. Zone of *Diplograptus folium*, His. (= Tullberg's zone of *M. convolutus*, His.)
5. Zone of *Diplograptus cometa*, Gein.
6. Zone of *Monograptus Sedgwicki*, Portl.
7. Zone of *Monograptus runcinatus*, Lapw.

In dealing with the description of the species the author has found it advisable to introduce a few new terms. He uses the term *prolific side* for that side of the sicula which communicates with the proximal cavity of the rhabdosoma; while he designates the opposite side the *dorsal side.* The term *virgella* is suggested for the so-called proximal prolongation of the virgula, which Wiman has shown to be no part of the true virgula, but a special filiform rod-like organ originating on the prolific side of the sicula.

The following species are described:—

DIPLOGRAPTIDÆ.

1. *Climacograptus scalaris*, His.
2. *Climacograptus medius*, sp. nov.
3. *Climacograptus rectangularis*, McCoy.

These three species cannot be distinguished when in a fragmentary condition. *C. scalaris* is characterized by a long distal prolongation of the virgula, and a very short virgella; *C. medius* has a long distal prolongation of the virgula, and also a long virgella; while in *C. rectangularis* the distal prolongation of the virgula is scarcely perceptible, and the virgella may be as much as 20 mm. in length.

4. *Climacograptus undulatus*, Kurck. (= *C. internexus*, Törnq. This species is characterized by its zigzag septal groove.)
5. *Diplograptus palmeus*, Barr.

6. *Diplograptus folium*, His.
7. *Diplograptus acuminatus*, Nich.
8. *Diplograptus cometa*, Gein.
9. *Diplograptus tamariscus*, Nich.
10. *Diplograptus bellulus*, Törnq.
11. *Diplograptus cyperoides*, sp. nov. (These two last species have no septum at all.)
12. *Diplograptus longissimus*, Kurck.

HETEROPRIONIDÆ.

13. *Dimorphograptus* cf. *Swanstoni*, Lapw.

This form differs from the true *Swanstoni* in having a longer sicula, and in the fact that the monoprionidian portion is curved and the diprionidian portion straight, while in Lapworth's species the whole rhabdosoma is curved. Törnquist suggests that if these features prove constant the name *Kurcki* should be given to the variety.

G. L. E.

II.—CATALOGUE OF TERTIARY MOLLUSCA IN THE DEPARTMENT OF GEOLOGY, BRITISH MUSEUM (NATURAL HISTORY): PART I, THE AUSTRALASIAN TERTIARY MOLLUSCA. By GEORGE F. HARRIS, F.G.S. 8vo; pp. i–xxvi, 1–408, with eight plates. (London: Printed by order of the Trustees. Dulau & Co., 37, Soho Square, W. Price 10s.)

THE Catalogue of the Cephalopodous Mollusca, by Dr. A. H. Foord, commenced in 1888 (of which the third part, by Messrs. Foord & Crick, is just out), together with the Systematic List of British Oligocene and Eocene Mollusca, by Mr. R. Bullen Newton, in 1891, were the only volumes published on the Fossil Mollusca in the Geological Department until the present work appeared. Mr. George F. Harris has made an excellent commencement in Part I with the shells of Australasia, and we may hope in a few years to see a series of similar Catalogues by him of all the important groups of Fossil Mollusca issued by the Museum.

Great difficulty must always exist in dealing with the fossil mollusca by reason of the absence of the animal, the systematic worker being compelled in consequence to rely on shell-characters alone, and he must institute most careful comparisons with living forms, as well as with the contemporary fossil ones from other localities.

Mr. Harris has devoted much time to the study of both Recent and Tertiary Shells, and in conjunction with Mr. H. W. Burrows, he communicated a most valuable Memoir to the Geologists' Association (April 3, 1891) on "The Eocene and Oligocene Beds of the Paris Basin," which was printed and published as a separate part of their Proceedings on September 23 of the same year (pp. viii and 130), with a geological map and thirteen sections. He also published in 1891 an admirable Table giving an approximate correlation of the Tertiary Beds of Europe, accompanied by explanatory notes, as a supplement to Mr. R. B. Newton's List of Oligocene and Eocene Mollusca above referred to.

Before attacking the Tertiary Mollusca of Australasia Mr. Harris had the advantage of previously visiting and collecting from very many of the classic localities in France, Belgium, Germany, Italy, and Britain, as well as to a limited extent in Spain, Northern Africa, and the United States; also of studying many foreign museums, and of working over the French, Austrian, Italian, and British Collections in the National Museum, so that he has had excellent training for working out those from the Antipodes.

The present work embraces collections made by the late Hon. Walter Mantell, Sir James Hector, K.C.M.G., F.R.S., and others from New Zealand; by W. H. Grigson, Esq.; by John Dennant, Esq., F.G.S., and others from Victoria; the Count Strzelecki, and others from Tasmania; by Commodore Goodenough, R.N.; by Henry Y. Lyell Brown, Esq., F.G.S.; by R. Litton, Esq., and others from South Australia.

The most beautiful specimens described in this Catalogue are undoubtedly those obtained from the Murray River deposits, and from Muddy Creek, Victoria; amongst these may specially be mentioned the great *Cypræa* (*Erosaria*) *gigas*, the largest known species of *Cypræa*, living or fossil, presented by John Dennant, Esq., who is also the donor of many other Tertiary shells from Victoria, which now adorn the cases in the Molluscan Gallery VIII of the Geological Department. ***Conus Newtoni***, sp. nov.; ***Pleurotoma septemlirata***, sp. nov.; ***P. subconcava***, sp. nov.; ***Drillia oblongula***, sp. nov., and ***D. vixumbilicata***, sp. nov.; ***Voluta lirata***, Johnston; ***Mitra multisulcata***, sp. nov.; ***Latirus Tatei***, sp. nov.; ***Murex Otwayensis***, sp. nov.; ***Strombus denticostatus***, sp. nov.; ***Tylospira coronata***, Tate (sp.); ***Cerithium apheles***, Tenison-Woods; ***Emarginula Wannonensis***, sp. nov.; ***Liotia Roblini***, Johnston; ***Turbo Hamiltonensis***, sp. nov., and ***Turbo Etheridgei***, Tenison-Woods, are justly figured as new or interesting forms of shells from Australia.

A considerable space is taken up in the Plates in this work with drawings of the "protoconch" in *Tornatellæa*; *Adelactæon*; *Ringicula*; *Terebra*; *Conus*, *Leptoconus*, *Lithoconus*, *Chelyconus*; *Pleurotoma*; *Columbarium*; *Teleochilus*; *Daphnella*; *Harpa*; *Volutilithes*; *Lyria*; *Voluta*, *Pterospira*, *Aulica*, *Volutoconus*, *Amoria*; *Scaphella*; *Mitra*, *Cancilla*; *Uromitra*; *Conomitra*; *Fusus*; *Latirus*; *Leucozonia*; *Tritonofusus*; *Murex*; *Pseudovaricia*; *Euthria*; *Phos*; *Nassa*; *Lotorium*; and *Turritella*. Much reliance is placed by the author on this earliest (Embryonic) stage of shell-growth as a means of working out phylogeny. To the same end he also adopts four other stages: 2, Brephic; 3, Neanic; 4, Ephebic; 5, Gerontic;—or in common parlance: 1, Embryonic (generally passed in the egg); 2, Infancy; 3, Youth; 4, Adult; 5, Old Age, or senile stage.

Of course it is only in a few shells that we can distinguish any very strong contrasts, corresponding to these periods of life; but we can usually detect clearly, the Embryonic, the Ephebic, and the Gerontic stages; as to the Brephic and Neanic stages, they are not so easily defined in the Gasteropoda.

Curious and frequently eccentric as the Embryonic stage often appears to be in the Gasteropod, it is a question of some importance to ask whether the use of the *protoconch* can be relied upon as of general application for classificatory purposes in Fossil Malacology. Of course, in the study of extinct forms one is too often compelled to classify specimens upon imperfect materials, and in all such cases without having the soft parts of the animal to examine and compare; we must not, therefore, disparage the labours of the palæontologist, who honestly endeavours correctly to classify and name these testaceous remains and give us as truthful a report as possible of the molluscan fauna of the earth in past times.

We have said nothing concerning the fossil Lamellibranchiata from these Australasian deposits, but as they only occupy 93 pp. and number 54 genera, against 150 of Gasteropoda and Scaphopoda taking up 300 pp., this is not surprising. Nevertheless, at least one genus, occurring in the Australasian Tertiary beds, and also actually living on the Australian coast, the genus *Trigonia*, is of immense geological interest, being found fossil in all the Secondary rocks down to the Trias, and enjoying a worldwide distribution in the past.

We should like to suggest to the author that, as his work progresses, he should, if it be possible, try to map out these remnants of the Tertiary seas, and endeavour to give us an idea of the geographical distribution of the Mollusca of this past period so far as the collections at his disposal may serve to enable him to do so.

The work is carefully performed, and promises well for future volumes, which we hope will speedily follow.

III.—CATALOGUE OF THE FOSSIL CEPHALOPODA IN THE BRITISH MUSEUM (NATURAL HISTORY): PART III, CONTAINING THE BACTRITIDÆ AND A PART OF THE SUBORDER AMMONOIDEA. By ARTHUR H. FOORD, Ph.D. (Münch.), F.G.S., and GEORGE C. CRICK, Assoc. R.S.M., F.G.S. 8vo; pp. xxxiv and 304 (with 145 illustrations in the text). (London: Printed by order of the Trustees, 1897. Dulau & Co., 37, Soho Square, W. Price 12s. 6d.)

THAT an interval of six years should have occurred since the issue of Part II of this Catalogue, suggests to the ordinary mind the slow movement characteristic of most geological agencies conducted on strictly Uniformitarian lines (not on cataclysmic action, as recently advocated in this Magazine by Sir Henry Howorth!). The delay in publication is mainly due to the transplanting of the original author of the work, Dr. A. H. Foord, from London to Dublin, a process which, although it has greatly retarded the issue of the present work, has, we trust, proved highly beneficial to him in more than one direction—as it happened to the patriarch long ago when he travelled to Padan-aran!

One important change which has resulted from Dr. Foord's removal from London, has been to throw a larger share of the work upon Mr. G. C. Crick; indeed, without his co-operation as joint author the volume could never have been completed. It is satisfactory to learn that, with the exception of the delay in delivery, the Catalogue itself has not suffered loss, Mr. Crick remaining on the spot and carrying on the work after Dr. Foord's departure with loyal good-will; and now by their joint labours we have Volume III of this useful Catalogue delivered bound in its customary cloth covering.

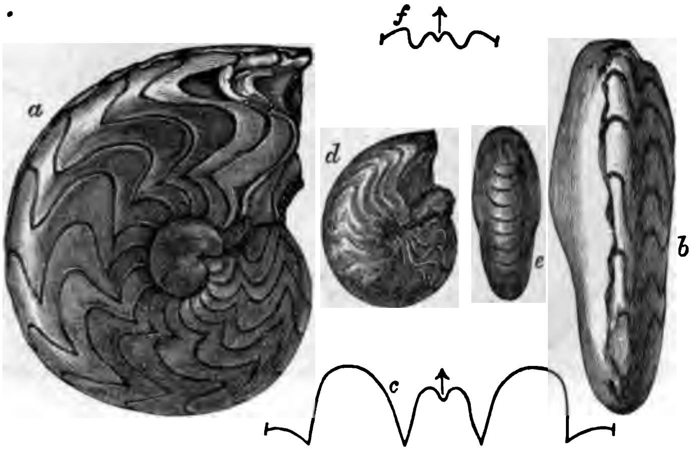


Fig. 1.—*a*, *Gephyroceras intumescens*, Beyr.; lateral view of a natural cast, from the Upper Devonian, Frasnes, Belgium; half nat. size. *b*, peripheral view of same specimen. *c*, suture-line of same. *d*, *Tornoceras simplex*, Von Buch; lateral view of a natural cast, from the Upper Devonian, Budesheim, Eifel; nat. size. *e*, peripheral view of same. *f*, suture-line of same species. (Fig. 25, p. 69, op. cit.)

Writing six years ago, Dr. Foord observed, in the Introduction to Part II, p. xvii, that in an earlier published Table of the Nautiloidea he had inserted the family Bactritidæ; but on reconsidering the question of the affinities of *Bactrites* (the sole representative of the family) in the light of the investigations of Branco and Hyatt, he was now prepared to accept the systematic position assigned to it by those authors—that is, at the commencement of the Ammonoidea. *Bactrites*, therefore, forms the subject of the opening chapter of Part III. Here under the genus *Bactrites* Dr. Foord gives us a summary of Hyatt's and Branco's investigations, and reproduces a series of interesting figures by Branco and others of the initial chambers of *Nautilus pompilius* (fig. 1, *a*, *b*, *c*, p. 41); of *Orthoceras elegans* (*d*); of *Cyrtoceras cornu* (*e*); of *Cosmoceras ornatum* (*f*, *g*, *h*); of *Belemnites Württembergicus* (*i*); of *Bactrites Hyattii?* (*k*); of *Bactrites gracilis* (*l* and *m*); of *Goniatites compressus* (*n*); and of *Spirula Peronii* (*o*).

After describing the initial chamber of *Bactrites*, of Nautiloids, Ammonites, Goniatites, Belemnites, and Spirulids, he points out that the shape of the initial chamber in *Bactrites* differs widely from that of the Nautilids, but agrees with that of *Goniatites compressus*.

These embryological studies of the shell bring out also most clearly the fact that in the earliest stages the great divisions of the Cephalopoda converge towards each other, and we arrive nearer to a common radical for the whole. Hence the difficulty which some authors have felt in deciding whether the genus *Bactrites* has stronger affinities with *Goniatites* or with *Orthoceras*.

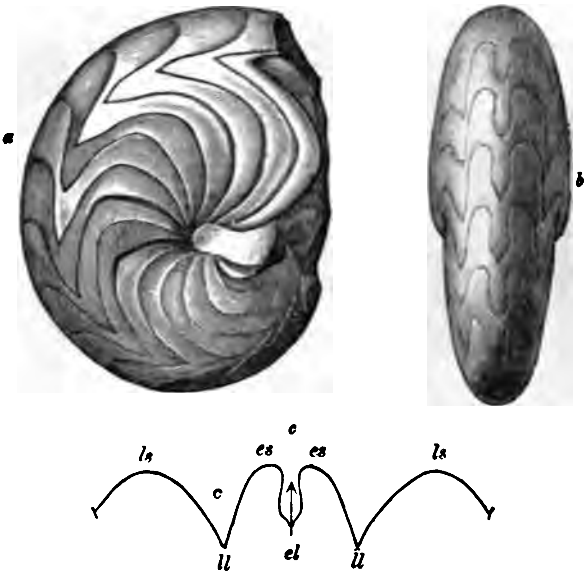


FIG. 2.—*Brancoceras Ixion*, J. Hall, sp. *a*, lateral view of a natural cast, from Goniatite Limestone, Kinderhook Group, Rockford, Indiana; *b*, peripheral view of same; *c*, suture-line; *el*, peripheral lobe; *es*, peripheral saddle; *ll*, lateral lobe; *ls*, lateral saddle. ¾ nat. size. (Fig. 62, p. 132, op. cit.)

The authors give us a clearly defined, yet comprehensive diagnosis for the suborder AMMONOIDEA, as follows:—"Shell conical, involute (most forms), or partly involute and partly evolute (*Scaphites*); sometimes bent on itself at one or both ends (*Ptychoceras, Diptychoceras*), or hook-like (*Hamites*), or even turreted (*Turrilites*), etc., or essentially straight (*Baculites*). Aperture simple, or with variously-formed lateral and ventral expansions. Suture-line undulating, serrated, or with more or less numerous digitate branches. Siphuncle marginal, without internal deposits. Initial chamber spherical or ovoid. Aptychus or anaptychus often present."

After discussing the merits of Dr. Paul Fischer's terms *Retrosiphonata* and *Prosiphonata*, the authors mention that Dr. E. Haug has pointed out that the Ammonites are retrosiphonate in the young, and that sometimes the prosiphonate stage is not attained (as in *Tirolites*) until the shell has reached a tolerably advanced age, a little before the last chamber. Instead of these terms, therefore, they rely on the important character of the sutures and divide the mmonoidea into two groups, viz.: Group A, to include the Clymenias d Goniatites with more or less simple sutures; Group B, to clude the Ammonites with highly complex sutures.

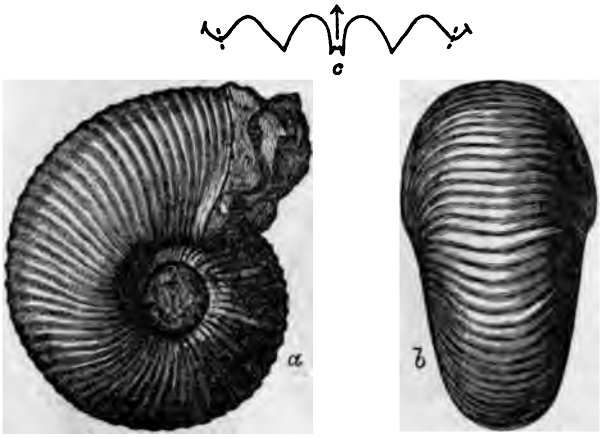
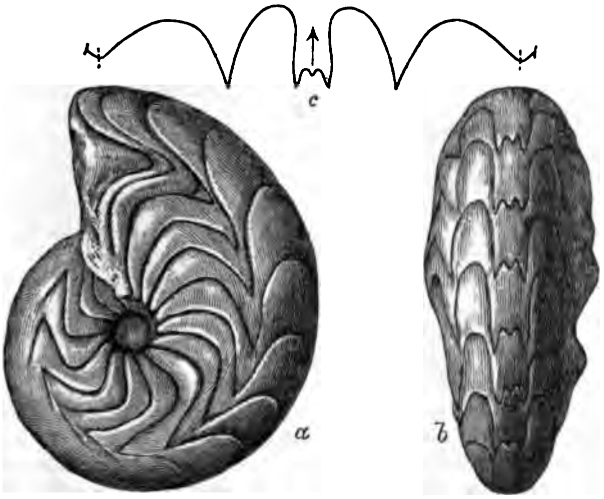


Fig. 3.—*Pericyclus Doohylensis.* *a*, lateral view; *b*, peripheral view; *c*, suture-e. (nat. size.) Carboniferous Limestone: Doohyle, near Rathkeale, co. Limerick, land. (Fig. 72, p. 151, op. cit.)

The present volume is entirely occupied with Group A, Ammonlea with more or less simple suture-lines, commencing with the nily Clymenidæ, and the one genus *Clymenia* and eight species;



ig. 4.—*Glyphioceras Hispanicum*, Foord and Crick. Carboniferous: Asturias, n. (nat. size.) *a*, lateral view; *b*, peripheral view; *c*, suture-line. (Fig. 91, 0, op. cit.)

the family Nautilinidæ containing the genera *Mimoceras*, *Anarcestes*, *Agoniatites*, and twenty-two species; the family Primordialidæ containing a single genus, *Gephyroceras*, with seventeen species; the family Magnosellaridæ, with the genera *Tornoceras*, *Mæneceras*, *Sporadoceras*, and twenty-six species; the family Glyphioceratidæ, with the genera *Brancoceras*, *Pericyclus*, *Glyphioceras*, *Nomismoceras*, *Dimorphoceras*, *Gastrioceras*, and fifty-eight species; the family Prolecanitidæ, with the genera *Sandbergeroceras*, *Prolecanites*, *Pronorites*, *Medlicottia*, *Agathiceras*, *Beloceras*, and seventeen species.

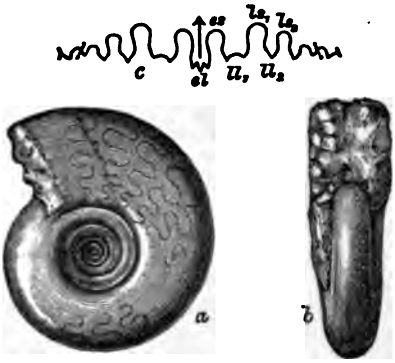


FIG. 5.—*Pronorites cyclolobus*, J. Phill., sp. *a*, lateral view; *b*, front view (nat. size); *c*, suture-line (letters to lobes and saddles as in Fig. 2; ll_2, second lateral lobe; ls_2, second lateral saddle). Carboniferous Limestone: Grassington, Yorkshire. (Fig. 125, p. 261, op. cit.)

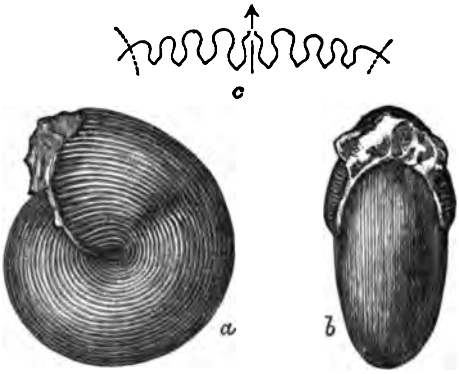


FIG. 6.—*Agathiceras Suessii*, Gemmellaro. *a*, lateral view, showing spiral ornamentation; *b*, front view, showing somewhat constricted aperture; *c*, suture-line. Permo-Carboniferous, Sicily. (Fig. 130, p. 269, op. cit.)

Group A is an interesting one, but in wealth of variation in form and in richness of suture-lines and ornament, Group B must necessarily far surpass it; nevertheless, we cannot fail to observe the gradual passage which takes place from the more simple forms to the more ornate forms with more complex suture-lines, as is well shown in the Prolecanitidæ, by such genera as *Medlicottia*, *Sandbergeroceras*, *Gastrioceras*, etc.

The aptychi of *Goniatites* from the Upper Devonian, near Herborn, Nassau, are described and figured. There are, indeed, no fewer than 145 illustrations in the text, some of which are of very beautiful forms, as *Gastrioceras Jossæ* (fig. 109); *Glyphioceras Hispanicum* (fig. 91); *G. fimbriatum*; *Pericyclus Doohylensis*; *P. princeps* (fig. 68); *Prolecanites compressus* (fig. 116); *Agathiceras Suessii* (fig. 130).

The Introduction furnishes a useful summary of the Bibliography of the Goniatites and their allies, of which Group A is chiefly composed.

The Triassic Ammonites, on which Mojsisovics has laboured so long and so successfully, will probably fill Part IV; this we hope will shortly follow the present volume. Beyond these lie the Ammonites of the Jurassic and Cretaceous formations, and the hosts of the Belemnites, the Squids, and Cuttles! We can only congratulate the authors and wish them "more power"; we may even venture to suggest that they may find it needful to take more hands aboard and hoist more sail, or the "Argonaut" will never reach her port.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 12, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Gravels and associated Deposits at Newbury (Berks)." By E. Percy Richards, Esq., F.G.S.

After a general sketch of the geology of the Valley of the Kennet, the superficial deposits at and in the neighbourhood of Newbury are described in detail, from observations made by the author during the progress of the main drainage works in 1894.

The author classifies the strata which he has examined in five groups—

(1) The Preglacial Southern Drift.
(2) The Glacial Drift (Donnington).
(3) The Upper River-gravel.
(4) The Lower River-gravel.
(5) The Neolithic peat-beds (shell-marl, peat, and loam).

(1) The first of this series is the flint-gravel constituting the heathy Commons north and south of Newbury (as of Snelsmore and Greenham). About 6 feet of gravel is exposed at the average level of 440 feet above Ordnance datum. It was referred to the "Southern Drift" by the late Sir Joseph Prestwich. At the edges of the Commons some of this gravel slips down and mixes with glacial deposits of later age.

(2) North of the town are the Glacial Gravel and Loam of Donnington and the Bath Road (17 feet), ranging from 254 to 300 feet above O.D. At the confluence of the Lamborne and Kennet Valleys these beds have been much denuded. The thickness, character, and composition of these deposits, as well as those of other gravels, etc., described hereafter, have been carefully noted by the author.

(3) The River-gravels of the Kennet Valley are of great interest, and have been carefully studied by the author at their several exposures, in Bull's Lane, the Enbourne Road, etc. Here the Upper River-gravel forms fine broad terraces at about 260 feet O.D. Palæolithic flint implements are not uncommon in this gravel. Bones and teeth of mammoth, common and extinct ox, sheep, pig, horse, and reindeer have also been found in it. Immediately north of Newbury this terrace is cut off locally from the town by an east-and-west fault at Northcroft, but is distinct a little farther to the west.

(4) The Lower River-gravel lies in the middle of the valley under the peat-beds of Newbury, and rests on the Chalk. It appears to have been derived from all the other gravels, but with a large percentage of flints direct from the Chalk. It is about 10 feet thick locally, and at some places has a white clay at its base.

The author finds that this gravel forms ridges across the valley, which seem to have been the limits of shallow-water areas, in which peat-bogs and clear pools with river-shells were locally produced (5), giving rise to patches and alternations of peat and marl. These varied in extent and in thickness, according to the damming-up of the lakes and their being drained by the currents causing gaps in the gravel-barriers, which are more or less easily traced. The peat varies from mere seams to beds 5 or 6 feet in thickness, and the marl from a few inches to 8 feet. The shells and bones found in the peat and shell-marl are enumerated, much as in earlier lists; so also are the plant-remains.

Above the peat-beds in the town of Newbury about 4 feet of coarse triturated gravels represent layers of road-material laid down in Roman and mediæval times; these are blackened with ancient sewage, and contain various metal and other relics. Cannon-balls fired from Donnington in 1644 A.D. occurred only 18 inches below the road-surface; "macadam" has been accumulated on the top to a thickness of 2¼ feet. A pile-structure of fir-wood was discovered in the peat in St. Bartholomew Street.

[Full references to published memoirs on the subjects of this paper and some additional Notes are given in an Appendix; and Notes on the Mollusca are contributed by Messrs. A. S. Kennard and B. B. Woodward.]

3. "The Mollusca of the Chalk Rock: Part II." By Henry Woods, Esq., M.A., F.G.S.

The first part of this paper, dealing with the Cephalopoda, Gasteropoda, and Scaphopoda, appeared in the last volume of the Quarterly Journal (vol. lii, p. 68). In the present communication the author gives an account of the characters, synonymy, and distribution of the Lamellibranchia: 29 species are recognized, six being new. The genera represented are: *Leda, Nucula, Arca, Limopsis, Modiola, Inoceramus, Ostrea, Chlamys, Lima, Spondylus, Plicatula, Cardium, Cardita, Arctica, Trapezium, Corbis* ?, *Martesia* ?, and *Cuspidaria.*

In the concluding part the author compares the fauna of the *Reussianum*-zone (Chalk Rock) in England with that of other European areas, particularly N.W. Germany and Saxony. In the latter country the number of species in some groups—especially Gasteropoda and Lamellibranchia—is much greater than in England; this difference is probably due to the sea having been of less depth than in the English area. It is noticed that the species of Cephalopoda have a much wider geographical range than the other groups of the Mollusca.

Finally, by a study of the present distribution of those genera—which form the predominating element in the fauna—taken in conjunction with the other characters of the zone, the author arrives at the conclusion that in England the *Reussianum*-zone was probably formed between the depths of 100 and 500 fathoms.

CORRESPONDENCE.

ACANTHONAUTILUS BISPINOSUS.

SIR,—Mr. Foord will find the first cousin, if not the brother, of his *Acanthonautilus bispinosus*[1] figured in "Matériaux pour la Palæontologie Russe," Tom. i, 1869, in Tab. v of a paper by Golowkinsky on the Permian formation of the central part of the Kama-Volga basin. It is there called *Nautilus cornutus.*

J. F. BLAKE.

GEOLOGICAL SOCIETY, BURLINGTON HOUSE, W.
April 12, 1897.

ACANTHONAUTILUS: A CORRECTION.

SIR,—In the April number of the GEOLOGICAL MAGAZINE appears a description of *Acanthonautilus* as a new genus. As this has already been published in Dr. Foord's Inaugural Dissertation (München, in 1896), "Ueber die Orthoceren des Kohlenkalks [Carboniferous Limestone] von Irland, etc.," the statement that it is new is likely to mislead the student.

C. DAVIES SHERBORN.

540, KING'S ROAD, LONDON, S.W.
April 26, 1897.

SIR,—Since my paper on *Acanthonautilus bispinosus* appeared in your April number, my attention has been directed to a work in the Russian language ("Material for the Geology of Russia," vol. i, 1869), containing a paper by N. Golovkinsky, in which is figured and described a species—*Nautilus cornutus*—closely related to mine, though from a higher horizon, the Permian. From a study of the figures it is clear that the species are quite distinct. Thus, in *A. bispinosus* the shell expands rapidly, and has a broad and shallow hyponomic sinus; the spines (similar in structure in the two species) are nearly straight, and slightly inclined downwards. The septa are not numerous. In the Russian species, on the other hand, the shell is more slowly expanding, the hyponomic sinus small and inconspicuous, the spines slightly curved, and inclined upwards. The septa, only faintly indicated on the larger of the two specimens figured, are more numerous than in the Irish species. The siphuncle, not seen in *A. bispinosus*, is in *N. cornutus* subcentral, and inclined towards the inner margin of the shell; this is the case at least in the smaller of the specimens figured, which also shows in a section the slow expansion of the whorls.

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[1] GEOL. MAG., April, 1897, p. 147, Pl. VI.

The discovery of the Irish Carboniferous species shows that this peculiar type of Nautiloid had a wide geographical range, while its appearance in the Permian of Russia extends its range in time.

The work in which *N. cornutus* is described seems to have been generally overlooked, as I have seen no reference to it even in books and papers dealing exclusively with Carboniferous or Permo-Carboniferous fossils.

My thanks are due to you, Sir, for your courtesy in allowing me to see Professor Blake's letter, thus enabling me to compare and comment upon the two species; and to Professor Blake science is indebted for having drawn attention to this "first cousin" of *A. bispinosus*. ARTHUR H. FOORD.

DUBLIN, *May* 13, 1897.

P.S.—With reference to Mr. Sherborn's letter which you have also kindly granted me the privilege of perusing, I can only say that I did not consider that the private distribution of a few copies of a paper could fairly constitute publication. The fact, however, seems to be that when once a paper has left its author's hands, and can therefore be quoted, it must be considered as published. I am obliged to Mr. Sherborn for pointing this out to me; I could have no better authority to guide me in the matter than his.—A. H. F.

MISCELLANEOUS.

"THE Distribution of Drift in Ireland in its relation to Agriculture" is the title of a paper by Mr. J. R. Kilroe (Proc. Royal Dublin Soc., ser. 2, vol. viii, 1897, pp. 421–431: published separately, price 6*d*.). It is accompanied by a geological map, printed in colours to show the areas where the more solid rocks appear at the surface, the large tracts (two-thirds or more of the country) which are covered by various drift deposits being left blank. As the author rightly points out, a map that would meet the requirements of the agriculturist must show, on a fairly large scale, the distribution of the subsoils, and indicate not only the materials of which they are composed, but their thicknesses at different localities, and in some cases the subjacent strata. This could be indicated by colours, letters, and numbers; and the author's aim is to make suggestions towards this object. He appends a table showing the nature of soils, subsoils, and boulder-clays in various parts of Ireland.

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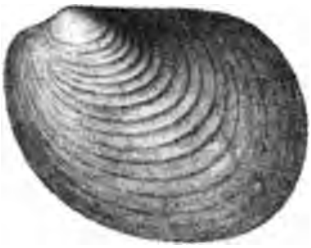

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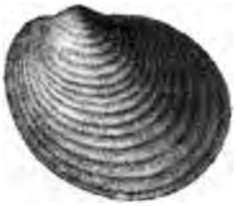

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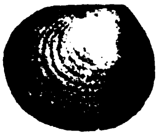

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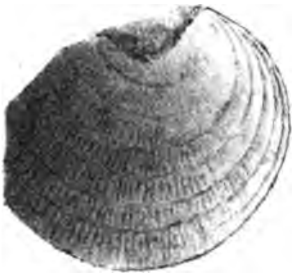

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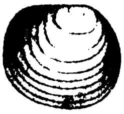

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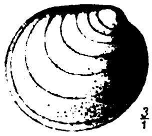

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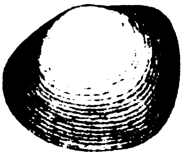

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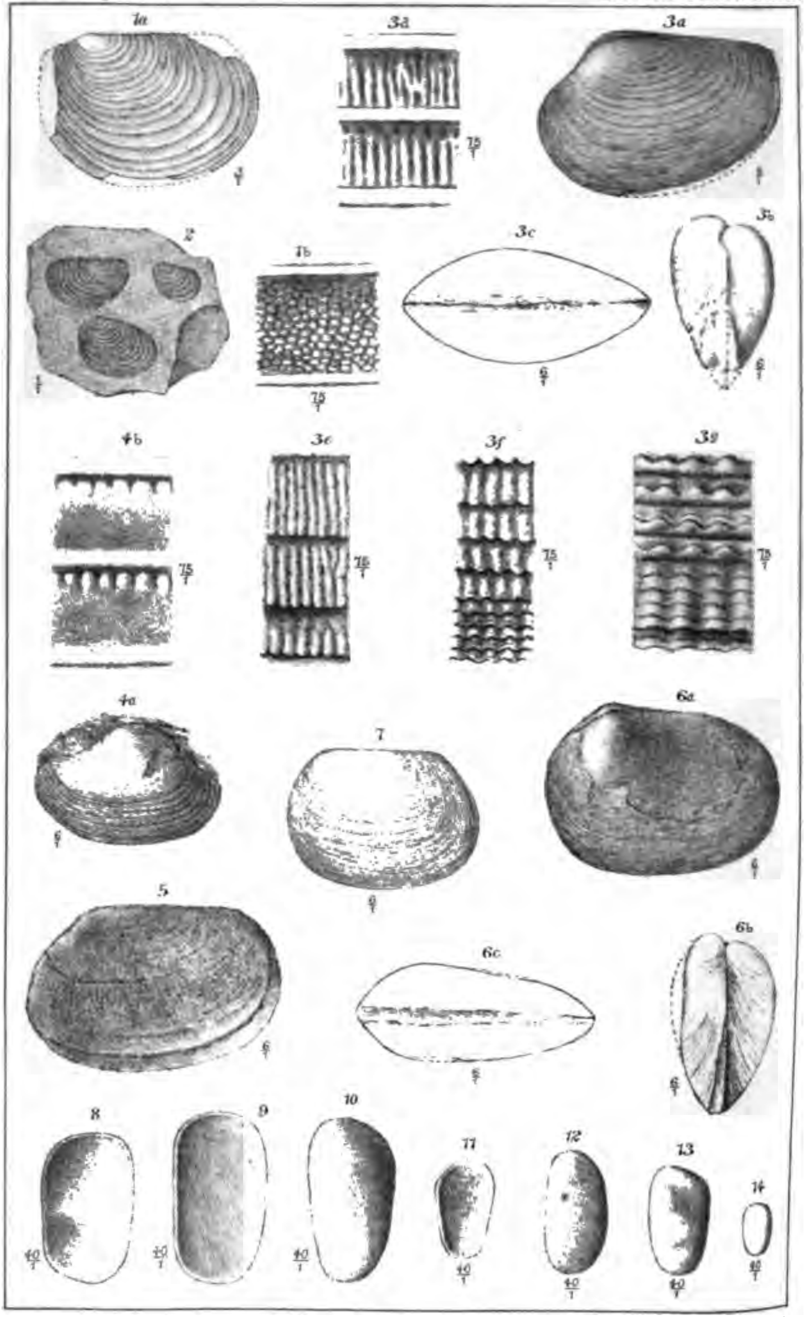
SOUTH-AMERICAN AND OTHER ESTHERIÆ.

Geol. Mag. 1897. Dec. IV. Vol. IV. Pl. XI.



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FOSSIL ENTOMOSTRACA FROM SOUTH AMERICA.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. VII.—JULY, 1897.

ORIGINAL ARTICLES.

◆

I.—On some Fossil Entomostraca from South America.

By Professor T. Rupert Jones, F.R.S., F.G.S.

(PLATES X and XI.)

PART II.

(*Concluded from the June Number*, p. 265.)

§ VIII. (4) Estheria Chilensis, Philippi.

PLATE X, Figs. 4, 5.

Estheria Chilensis, Philippi, "Tert. u. Quat. Verst. Chiles," etc., 1887, p. 223, pl. L, fig. 11.

Valves subcircular, approaching subquadrate, like some small Lamellibranchs. Umbo at the antero-dorsal corner, and at an angle of 40° to the extreme curvature of the concentric ridgelets. Hinge-line straight, behind the umbo, about half the length of the longest diameter of the valve. The other edges rounded; the anterior nearly semicircular; the ventral obliquely curving up to meet the steeper and narrower posterior curve.

Size.—Length, 6·4 mm.; breadth, 5·6 mm.

In the dark-coloured hard shale collected by David Forbes at Arica, Southern Peru.

This differs from the associated suborbicular *Estheria* in the Arica shale, both by its rounder shape and especially by the terminal position of the umbo. Also by its more symmetrically regular and more delicate lines of growth.

Lebu, on the coast of Chili, is given, with doubt, as the locality of Professor Philippi's *E. Chilensis*, Fig. 5.

This shape is not unusual among young forms; for instance, the young *E. Forbesii*, "Monogr. Foss. *Esth.*," pl. iv, fig. 9; but the marginal contour differs all round, and the Arica specimen has more numerous ridgelets. The adult form of *E. Forbesii* differs still more distinctly.

The figure of *Estheria* associated with *E. elliptica* in the "Monogr. Foss. *Esth.*," pl. iv, fig. 3, already referred to as an analogue of *Cyclestheria*, may be again quoted, as having a form somewhat like our Fig. 4, though more subquadrate and oblique.

Although there is evidently a close alliance, as far as outward form is concerned, between *Estheria Chilensis* and *Cyclestheria*, Fig. 6, it would be impossible, without more knowledge of the internal structure, to recognize a generic identity.

An approach to this rare form (*Cyclestheria*) among *Estheria* is seen on pl. iv, fig. 3, "Monogr. Foss. *Estheriæ*," a right-hand valve of a small form (possibly a variety) of *E. elliptica*, from the Purbeck of Hanover, and already referred to.

Both Forbes's specimens and Philippi's outline are matched to some extent by Krotow's *Estheria subconcentrica*, Fig. 7, from the "Lower Permian" formation of the Urals;[1] but this apparent alliance is not sufficient to give a geological horizon to the Arica shales. The doubt, moreover, of the locality and geological horizon whence *E. Chilensis* really came, further obscures the possible relationship of these *Estheriæ*.

§ IX. SZAJNOCHA, 1888.

In the "Verhandl. k. k. Geol. Reichsanstalt Wien," 1888, pp. 146, 147, Dr. L. Szajnocha refers to specimens collected by Dr. Rudolf Zuber in South Argentina and Patagonia, especially plant-remains, such as characterize Triassic or Rhætic strata in Australia, South Africa, Germany, Portugal, and Scania. He notices that at Cacheuta shales with plant-remains and phyllopoda occur, and that the latter were described by Geinitz as *Estheria Mangaliensis*, Jones, in his Memoir (1876) on these and other Rhætic plants and animals.

§ X. SUMMARY OF THE FOREGOING NOTES.

These result in the determination of four species of *Estheria* found fossil in Peru and Chili, namely—

1. *Estheria Mangaliensis*, Jones, Mangali in Central India, and Mendoza in South America.
2. *E. Forbesii*, Jones, Mendoza, South America.
3. *E. Aricensis*, sp. nov., Arica, South Peru.
4. *E. Chilensis*, Philippi, Lebu (?), Chili; Arica, South Peru.

§ XI. ESTHERIA MAWSONI, sp. nov., and var.

There is also another South-American *Estheria* preserved in the British Museum (Nat. Hist.), and forming part of Mr. J. Mawson's Collection from Brazil, namely (5) *Estheria Mawsoni*, sp. nov., and (5^a) variety.

(5) ESTHERIA MAWSONI, sp. nov.

PLATE XI, Figs. 3*a*–*g*.

Carapace obliquely subovate, moderately gibbose. Umbones at the anterior third of the valve. Hinge-line straight from the umbo to the posterior end, and equal to about two-thirds of the length of the valve. Hinder moiety of the carapace smaller than the front part, the posterior curve being more contracted than the antero-ventral curve. Hence the carapace has a triangular subovate side-view.

Concentric ridgelets or lines of growth, numerous: more than thirty, although those on the umbonal area are obsolete or obliterate. These ridges on the upper part, just below the umbones, are strong, ith rounded and smooth edges, Fig. 3*d*; thinner and smaller lower own on the valve.

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[1] Mém. Com. Géol. (St. Petersburg), vol. vi, 1888, pp. 469 and 556, pl. ii, fig. 26. See also Brit. Assoc. Report for 1889, p. 66.

The interstitial spaces are broad on the upper or dorsal moiety of e valves, more and more closely set below, as in other adult *Estheriæ*. he ornament in the broad interspaces consists of small vertical ars, or barrolets, slightly sinuous (Figs. 3*d*, *e*), and occasionally ranching and anastomosing to some extent. Towards the free argin, in the narrower intervals, the barrolets become shortened, d merge into a wavy and crenulate pattern (Figs. 3*f*, *g*).

Two carapaces, "L. 304." 1. Long, 7·0 mm.; high, 4·0 mm.; ick, 2·6 mm. 2. Long, 5·7 mm.; high, 3·6 mm.; thick, 3·0 mm. vate-oblong, anteriorly short. From shale in a cutting on the Bahia d San Francisco Railroad, 12–13 kilometres from Bahia, on the seade, between Periperí and Olaria; together with some small Molluscs -*Anodonta Hartii*, White, *A. Mawsoni*, White, *A.*, sp., and *Arca*, sp. here are also other specimens, more or less flattened and demposed, in sandy shales and clay from cuttings at Pitanga, Pojuca, nd elsewhere.

With regard to the ornamentation of this species, two recent rms, *Estheria donaciformis*, Baird,[1] and *E. similis*, Baird,[2] have bar-ornament in the interstices, of much the same character as at in Figs. 3*d*–*g*, though not so regularly parallel. The valves, owever, do not correspond with ours in shape.

Among fossil forms *E. elliptica*, Dunker, and *E. subquadrata*, owerby, are characterized by the ornament of vertical bars between e concentric ridges, much like those of *E. Mawsoni*. The shape, owever, of the valves in these Purbeckian forms[3] differs from that f the Brazilian species under notice. There is evidence of a similar rnament in some fragments of *Estheria* from the Triassic or Rhætic al-shales of Dan River, North Carolina.[4] An analogous pattern is resent on the shells of some bivalved Mollusca, as *Corbis*, etc.

(5°) ESTHERIA MAWSONI, sp. nov., variety or female form.

PLATE XI, Figs. 4–6.

Ovate-oblong, umbo near the anterior end, in the front fourth f the dorsal edge; postero-dorsal angle more or less distinct; inge-line straight between these two points, and equal to more an half the length of the valve. The front and hind margins ave a steep curve, and are more equal than in *E. Mawsoni*, Fig. 3*a*. ut the posterior moiety of the carapace is rather smaller than the nterior; its edge having a somewhat smaller curve than the broad, lmost semicircular, curvature of the front end.

This form differs from *E. Mawsoni* (described above) in being early oblong in side-view; the front edge curving steeply below e umbo; and the posterior not being contracted. The difference of shape may possibly be due to sexual condition, since the ornamentation is quite the same on the two forms.

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[1] Proc. Zool. Soc., Annulosa, 1849, p. 89, pl. xi, fig. 5.

[2] Ibid., 1849, p. 90, pl. xi, fig. 7; and 1860, p. 188.

[3] "Monogr. Foss. *Esth.*," 1862, p. 103, etc., pl. iii, figs. 18–29; and GEOLOGICAL AGAZINE, 1890, p. 389, Pl. XII, Figs. 1, 2.

[4] "Monogr. Foss. *Esth.*," 1862, p. 189, etc., pl. ii, fig. 37; and GEOLOGICAL AGAZINE, 1890, p. 387.

Approximately similar valves are found in the varieties of *E. minuta* and its allies. This form is somewhat like the carapace of the female *E. Packardi*, as figured by Sars.

Flattened casts of the valves occur in brownish shales and in pink clay in the Pitanga and Pojuca cuttings. A carapace from the cutting between Periperí and Olaria measures: Long 5·0 mm., high 3·5 mm., thick 2·5 mm.

Estheria Mawsoni or its variety occurs

At 12–13 kilometres. The cutting between Periperí and Olaria.

At 73–74 kilometres. The Pitanga cutting, between Matta and Pitanga Stations.

At 82 kilometres. At Pojuca Station.

At 84·5 kilometres. At San Thiago (Säo Jago), about six kilometres from the Pojuca Station.

Fig. 5 shows an internal cast with delicate radiating marks, due to the decomposition of the test and its outer layer.

There seems to be a still more truly oblong *variety* of this species, Fig. 7.

§ XII. Ostracoda.

A number of small valves occur in the same soft brownish shale in a cutting at 83 kiloms. between the Station of Pojuca and San Thiago, on the railroad from Bahia, that yields *Estheria Mawsoni*, *Estheriïna expansa*, and *E. astartoides*. They lie crowded on some of the bed-planes, and are much obscured by the matrix and imbedment.

In Plate XI the most recognizable forms are depicted (Figs. 8–14); but it is difficult to define their characteristics. Figs. 8 and 9 may belong to an oblong form of *Cythere*; so also Fig. 14, but this is small and nearly oval. Figs. 10 and 11 may be subtrigonal *Cythere* or *Cytheridea*, with the anterior hinge sufficiently strong to influence the outline of the valve. So also Fig. 13, but this valve has on its surface local depressions, which may possibly be indicative of the undulated or constricted valve of a *Metacypris*: see Geol. Mag. 1886, pp. 145–8, Pl. IV, Figs. 1–3; and ibid., 1893, pp. 385–91, Pl. XV, Figs. 1–3. Fig. 12 may be a *Candona* or a *Cypris*.

The general aspect of the Ostracoda is that of a group of probably brackish-water forms, agreeing therein with the associated Estherian phyllopods. Compare the analogous Brazilian specimens treated of in the Quart. Journ. Geol. Soc., vol. xvi (1860), pp. 266–7, pl. xvi, figs. 13–17.

§ XIII. Conclusion.

It is difficult to determine if the groups of fossil Entomostraca above described, represent the brackish-water conditions that obtained in the late Triassic (Rhætic) or the Jurassic and early Cretaceous (Wealden) times. The plant-remains of Mendoza appear to be of Rhætic age. The railway-cuttings in Brazil have not yielded any definite plant-remains; and their fossil shells have been referred to the Cretaceous system. *Estheriïna* is certainly characteristic of the Brazilian shales in Hartt's "Bahian" series; some of its analogues are far back in the Carboniferous system. *Estheria Forbesii* and *E. Mangaliensis* are such as lived in a late Secondary age;[1] *E. Mawsoni* has the ornament characteristic of some species of early Secondary, or rather earlier date.

EXPLANATION OF PLATE X.

Fig. 1.—*Estheria Aricensis*, sp. nov. Left valve, magn. 3 diam.
Fig. 2.—The same. Left valve, magn. 3 diam.
Fig. 3.—The same. A large specimen, drawn from a hollow mould of a left valve, magn. 3 diam.
Fig. 4.—*Estheria Chilensis*, Philippi. Right valve, magn. 3 diam.

Figs. 1–4, from Arica, Peru, collected by David Forbes, are in the British Museum.

Fig. 5.—*E. Chilensis*, after Philippi. Nat. size.
Fig. 6.—*Cyclestheria Hislopi*, after Sars. Magn. 3 diam.
Fig. 7.—*Estheria subconcentrica*, after Krotow. Nat. size.

EXPLANATION OF PLATE XI.

Fig. 1.—*Estheria Forbesii*, Jones. *a*, left valve, magn. 3 diam.; *b*, part of the superficial ornament, magn. 75 diam. From Cacheuta, Argentine; collected by D. Forbes, and in the British Museum.
Fig. 2.—A group of the same species, after Philippi. Nat. size.
Fig. 3.—*Estheria Mawsoni*, sp. nov. *a*, carapace, showing the left valve; *b*, end view; *c*, edge view. *a*, *b*, *c*, magn. 6 diam. *d*, *e*, *f*, *g*, parts of surface, magn. 75 diam.
Fig. 4.—The same, variety or ♀. *a*, left valve imperfect, magn. 6 diam.; *b*, part of surface, magn. 75 diam.
Fig. 5.—The same, variety or ♀. An internal cast of a left valve, showing radiating lines caused by the decomposition of the test and its minute interstitial barrolets; magn. 6 diam.
Fig. 6.—The same, variety or ♀. *a*, carapace showing left valve; *b*, edge view; *c*, end view: all magn. 6 diam.
Fig. 7.—The left valve of a variety of *E. Mawsoni*. Shorter and squarer than the other examples, magn. 6 diam.

Figs. 3–7 from the Bahia and San Francisco Railroad, at 12–13, 73–74, 82, and 84·5 kilom. from Bahia.

Figs. 8–14.—Small Ostracoda (possibly *Cythere*, *Cytheridea*, *Cypris*, *Candona*, and *Metacypris*); magn. 40 diam.

II.—On a New Specimen of the Stegocephalan *Ceraterpeton Galvani*, Huxley, from the Coal-measures of Castlecomer, Kilkenny, Ireland.

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE XII.)

SINCE the original description of *Ceraterpeton* by Huxley thirty years ago,[2] several specimens have been referred[3] to this interesting Stegocephalan genus, one even to the typical species,

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[1] See "Monogr. Foss. *Esth.*," Pal. Soc. 1862, Table, p. 114.

[2] Huxley and Wright, "On a Collection of Fossil Vertebrata from the Jarrow Colliery, County of Kilkenny, Ireland": Trans. Roy. Irish Acad., vol. xxiv (1867), p. 354, pl. xix.

[3] E. D. Cope, "Synopsis of the Extinct Batrachia from the Coal-measures [of Ohio]," Rep. Geol. Surv. Ohio, Palæont., vol. ii, pt. 2 (1875), p. 372, pl. xli, fig. 4; pl. xlii, fig. 2. A. Fritsch, "Fauna der Gaskohle," vol. i (1880), pp. 136–40, pls. xxvii–xxx.

C. Galvani.[1] No new examples from the typical locality, however, have hitherto been described, and our knowledge of the Irish form has thus remained without extension. Now, a nearly complete new skeleton has been discovered at Castlecomer, by J. G. Robertson, Esq., of Dublin, and I am indebted to him and to Professor Grenville Cole for the opportunity of studying it, and adding somewhat to the known characters of the animal.

Like the previous specimens, the new fossil seems to consist of little more than bituminous matter replacing the substance of the bony skeleton; but it stands in relief from the surface of the shale, and clearly exhibits the contours indicated in the accompanying outline sketch (Plate XII), which is of the natural size. The skeleton is exposed from beneath and wants only the absolute extremity of the tail.

The lateral borders of the head are covered by the slender mandibular rami (*md.*), which are a little crushed apart at the symphysis and allow the premaxillæ to be observed. Remains of a regular close series of small blunt teeth are conspicuous in front; while two teeth which seem to belong to the right mandibular ramus are somewhat larger than the others and a little tumid. The anterior part of the palate is destroyed, thus completely exposing the cranial roof from within. Part of the border of the orbits (*orb.*), in their characteristic forward situation, is clearly shown. The pineal foramen (*pin.*) is also well displayed. There is a distinct median suture between the frontal (*fr.*) and parietal bones; but the transverse suture between these elements is a little uncertain, though it seems to have been as indicated in the figure. As in the previous specimens, the posterior cornua of the skull seem to have been firmly fixed to the other elements. That of the right side is almost completely exposed, and its length is about equal to half that from the occiput to the end of the snout; its surface is quite smooth.

Immediately behind the head the axial skeleton is obscured by the crushed remains of the pectoral arch, which probably covers five or six vertebræ; but between this and the hind-limbs ten vertebræ are distinctly shown in regular series, each bearing a pair of very stout curved ribs. The vertebræ themselves are exposed in side view, showing the slender constricted centrum and the crushed remains of the expanded neural arch. The ribs are nearly uniform in size. The pelvic region is obscure, but it does not seem possible to count more than one vertebra as sacral. Then follow two caudal vertebræ with a stout backwardly directed rib firmly fixed to each transverse process. The remaining caudals must have been almost or completely destitute of these processes. About 25 of them are preserved in regular undisturbed series, turned upon their side, and displaying the characteristic fan-shaped neural and hæmal arches. These arches

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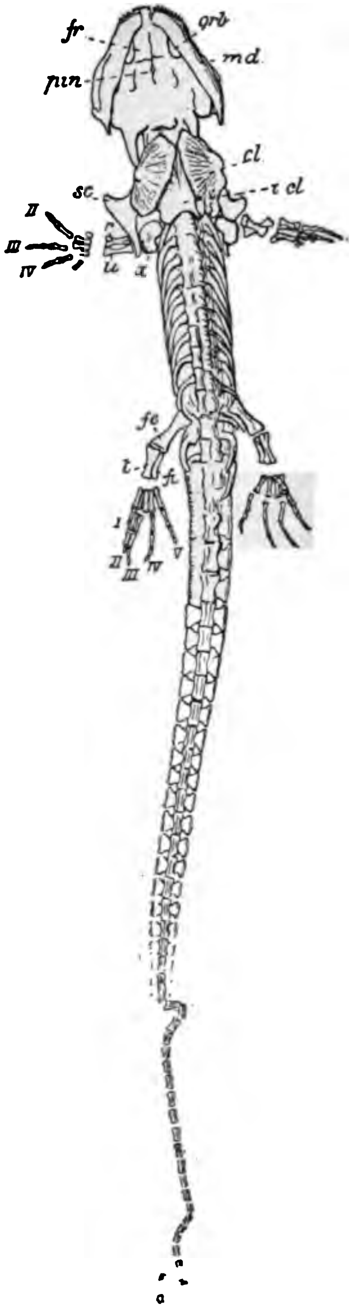
[1] J. Ward, "The Geological Features of the North Staffordshire Coal-Fields": Trans. N. Staff. Inst. Mining Engin., vol. x (1890), p. 187, pl. ix, fig. 2. C. W. Andrews, "Note on a Specimen of *Keraterpetum Galvani*, Huxley, from Staffordshire": GEOL. MAG., Dec. IV, Vol. II (1895), pp. 81–4, Woodcut.



Ceraterpeton Galvani, Huxley (nat. size).
Coal-measures: Kilkenny, Ireland.

form symmetrical pairs, gradually becoming atrophied towards the hinder members of the series, and their distal margin is in some cases distinctly crimped. At the twenty-seventh caudal vertebra, where nothing but the delicate elongated centra can be seen, the tail is a little distorted and the remainder is only imperfectly preserved; but there cannot have been less than 25 centra in this attenuated terminal portion. The caudal region is thus about three times as long as the abdominal region.

As already mentioned, the crushed remains of the pectoral arch are conspicuous immediately behind the head. The clavicles (*cl.*) are elongate-ovate in shape, and marked with a linear ornament which radiates from a boss on the outer lateral border of each. They distinctly meet in the middle line in front of the inter-clavicle (*i.cl.*), which tapers forwards, and seems to be fractured by crushing upon the vertebral column at its hinder border. The latter bone also shows feeble traces of a radiating ornament, but does not bear any longitudinal ridge. On either side of the clavicular apparatus, but partly obscured on the left, the internal element (*sc.*), provisionally termed scapula by Huxley, is well preserved, with the excavated triangular end forwards and the tapering pointed extremity directed backwards. The small, almost reniform bone (*x.*) touching the latter on the right, overlapping it on the left, may be either a coracoid or the crushed remains of the humerus. The radius (*r.*) and ulna (*u.*) are well displayed on both sides, those on the right in juxtaposition, those on the left crossing each other. The ulna is slightly the larger of the two bones, and there is some appearance of a small olecranon process. The carpus is represented by a blank space, and must thus have remained unossified. The digits are imperfectly preserved, a little crowded on the left, spread out on the right, and it is doubtful whether there are more than four. The metacarpals and all the phalanges except the unguals are a little expanded at each end, while the terminal elements just mentioned are relatively small, slender, and pointed. The first digit preserved on the right side is probably No. II, and exhibits three phalanges; the next digit, also complete on the left side, has four phalanges; No. IV on the right side has again only three phalanges; No. V is not satisfactorily displayed.

The fragmentary remains of the pelvis are too obscure for description, but the hind-limbs are well preserved. They are slightly larger than the fore-limbs and clearly exhibit five digits, each terminating in a relatively small and pointed ungual phalange. The femur (*fe.*) is robust and slightly expanded at each end, much longer than the tibia and fibula, indeed as long as the crus with the tarsus indicated by the vacant space. The tibia (*t.*) is also stouter than the fibula (*fi.*), and its proximal end is much more expanded than its distal end. There is no trace of ossification in the tarsus, but the five metatarsals and their appended digits are so well ossified that the bones may almost be described as terminated with complete condyles. The first digit (I) is relatively small and is crushed upon the second in both feet, but on the right side it exhibits two phalanges; Nos. II to V, of the proportions shown in the figure, are beautifully displayed on both sides, and their phalangeal formula is clearly proved to be 3, 4, 4, 3.

No impressions of the skin are preserved, and there is no trace of the scutes of the ventral dermal armour.

Mr. Robertson's new specimen of *Ceraterpeton* is thus of special importance as making known for the first time in the type-species the characters of the clavicular apparatus, the phalangeal formula of the hind-limb, and the relative proportions of the tail; for the fossil was obtained from the same formation and locality as the original specimens, and the only important differences it presents may easily be explained as the result of accident. On comparison it will be observed to differ a little in the shape of the head, which is relatively narrower; it also seems to differ in having two or three fewer presacral vertebræ. As Huxley remarks, however, the head in the two examples he figures is not improbably widened by crushing; while there may be a mistake in estimating the number of vertebræ covered by the clavicular plates in the fossil described above.

It now appears, indeed, that the amended diagnosis of *Ceraterpeton* based by Fritsch on specimens from the Lower Permian of Bohemia, does not apply to the genus with which Huxley was dealing when he originally proposed the name. It has already been pointed out by Andrews[1] that the skull of *Ceraterpeton* discovered by Ward in the Coal-measures of North Staffordshire, differs in most essential particulars from the Bohemian skulls ascribed to the same genus by Fritsch. It is now clear that there are equally important differences in the trunk and limbs. The species from Bohemia exhibits (i) more numerous presacral vertebræ and more slender ribs, (ii) a clavicular apparatus of entirely different shape, as interpreted by Fritsch, and (iii) distinct ossifications both in the carpus and tarsus. The generic name *Scincosaurus* originally applied by Fritsch[2] to the Bohemian specimens ought thus to be adopted for the species generally quoted under the name of *Ceraterpeton crassum*; while the only definitely known species of *Ceraterpeton* is the type. The skull from the Coal-measures of Ohio described by Cope under the name of *C. lennicorne* seems to be correctly placed here; but of this animal the trunk still remains unknown.

EXPLANATION OF PLATE XII.

Ceraterpeton Galvani, Huxley; outline of nearly complete skeleton, ventral aspect, nat. size. Coal-measures: Castlecomer, Kilkenny, Ireland. *cl.*, clavicle; *fe.*, femur; *fi.*, fibula; *fr.* frontal; *i.cl.*, interclavicle; *md.*, mandible; *orb.*, orbit; *pin.*, pineal foramen; *r.*, radius; *sc.*, supposed scapula; *t.*, tibia; *u.*, ulna; *x.*, coracoid or humerus. [Collection of J. G. Robertson, Esq., Dublin.]

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[1] Loc. cit. 1895, p. 83.

[2] Sitzungsb. k. böhm. Gesell. Wiss. 1875 (1876), p. 72.

III.—More Notes on the Terraced Hill Slopes of North Oxfordshire.

By Edwin A. Walford, F.G.S.

THE green slopes of many of the minor vales of North Oxfordshire are scored with parallel terraces or terraced banks frequently of such regularity in depth of step and slope as to present to the mind any other origin for their formation than that of the every-day work of natural forces. A student who has mastered the elements of this natural work and has gained a clue to the mode of the making of the terraces reads with some amusement the varied accounts of their human origin. The best summary of these accounts is given in Mr. G. L. Gomme's book "The Village Community."[1] And though these accounts refer to wider tracts of country than can be discussed here, our local antiquarians assign similar human causes, and we read of the terraced slopes as camps, entrenchments, vineyards, bear-gardens, and the like.

It continues to be so in the face of the fact that—

(1) The so-called vineyards present every face to the sun, and as frequently face N.E. as S.W.

(2) That the entrenchments would protect nothing, and occur in places impracticable for defensive work.

(3) And that as camps, the question of water supply is generally a fatal one to such use.

Now Mr. Gomme's catalogue runs thus:—

Elf furrows (human origin ?).

Places for militia to arrange themselves on—for the chieftain's review.

Roman works—itinerary encampments.

Terraces of cultivation.

Places for people to witness Druidical ceremonies.

The geological theories of Mr. Poulett Scrope, Dr. Mackintosh, and Dr. Darwin, I quoted in my paper printed in 1890.

I first briefly drew attention to the terraced fields in my account of "Edge Hill," published in 1886. Four years later, in the Journal of the Northamptonshire Natural History Society, I dealt with the subject at some length. Since then other localities and new conditions have come under my notice, and with them I propose to deal.

To cite again the causes of terrace formation: First and foremost is the downward *creep* of the surface and subsurface soil. But we are met by the objection that the soil creeps downwards from every hilltop, and that all high land is in a state of movement towards vale and sea: yet terraces do not occur upon every hillside.

Our home valleys give the clue. Almost all the terraces occur upon one precise geologic line. That line is a series of marls and clays, with variable proportions of sand, which come in below the red rock bed (the higher part of the zone of *Ammonites*

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[1] G. L. Gomme, "The Village Community," pp. 82-8. (Walter Scott, London, 1890.)

spinatus). The marls are porous, they are non-cohesive. The lime in them has either been removed, leaving them in a loose, incompacted state, or it is in process of removal by the constant saturation and passage of water. Oft-times we forget that the heated land-surface of summer-time must draw again from below that which it allowed to pass through.

Although it is common enough to see on hill slopes small terrace-like ridges caused by the downslide of surface soil, yet it is not until we reach the position of the marls of the Middle Lias that the downslide is made prominent, and that terraces, from an incipient stage like the ordinary grass ridge to minor and major terraced banks of varying regularity of form, can be traced. On these slippery slopes the soil must creep. The rain and rainwash loosens the light soil and marl below and about the roots of the herbage, and urges its movement downward. So, just as the children make ground-slides down the steep smooth banks, so the Earth-Mother makes these pleasant folds along the sides of her green vales as she strips away her waste for the use of the lower lands.

Below these slippery marls are depths of compact blue clay (the zone of *Ammonites margaritatus* if near the marls). A little below the point where the marls and clays meet is the line of water outflow—its course can easily be traced around every hill slope. Along this line there is constant removal of the marls by chemical and mechanical solution. The effect is the loosening and sliding of the beds downwards and outwards. The jumbled state of the land along the line is often evident; at Edge Hill it is very prominent. If there be "hummocky" ground it is thereabouts. The pressure of the overlying mass of rock (there twenty-five feet thick) with the associated marls has no doubt aided in the squeezing out of the soft beds along the water-line. Hence pressure appears as a factor in the making of terraces. The terraced slopes of the chalk hills and the lynchets of the sandy oolitic hill-caps of Dorsetshire frequently begin near the crest. The water-line of the former is probably the Gault, and of the latter the line is at the top of the clays of the Upper Lias.

Furthermore, it appears that the free passage of water *through* the rock and marl is necessary, for the Upper Lias Clays have on the Oxfordshire terraced hills either been wholly stripped from the hill-tops or have been pushed far back by atmospheric denudation. Regularly terraced slopes are not found under clay-caps; the clay cover may roof the hilltop, but the appearance of terraces is coincident with its wearing away from the top of the bank.

I have noted that the flats of the terraces, especially of the lower ones, are often water-soddened, but whether the flats have relationship to minor lines of outflow is not clear and is scarcely probable.

The amphitheatre form of terraced land is always a valley head. The outflow of the stream—the valley-maker—marks ordinarily the base of the amphitheatre. More frequently the terraces of the valley head are small in step, their curvature is broken, and the depth of step irregular. Such an instance is Kenhill, near Shennington; an instance of greater regularity of curvature and greater depth of step is the Bear-garden, Banbury. It has been described as a Roman amphitheatre, and its name Bear-garden indicates a probable former use.

The best instances I can cite are the terraced banks of Rattlecombe Slade and the adjoining ground near Shennington, which I described in my previous paper. The Shennington valley, as well as the Horley and Hornton vale, begins near the Edge Hill escarpment and flows from its ridge onwards in a south-westerly direction towards the Cherwell vale. Around the high lands above Hornton, where the Hornton vale begins, are some terraces, and also its slopes are terraced in its course towards Horley. Miniature terraces made by the down-drift of soil may be seen on the west side of the brook below the hedgerow of the ploughed field and high up the bank. The names Fermere[1] Lake and Angermere Hill suggest the former spread of water over the vale, and in the black peaty soil of Angermere Hill-side the remains of large deer have been found. Another fork of this vale runs alongside Adsum (or Hadsham) plantation, and in part is known as Adsum Hollow. The terraces sweep in regular curves alongside the high banks of the stream, and where it joins the main vale to the north of Horley the steps are of so prominent a type as to give the name of Steps Meadow to the ground. The highest terrace gives the greatest depth of step, but the contour of the top terrace is usually less regular than that of the two or three lower ones. The beautiful terraced slopes which cover the three sides of Gredenton Camp on the Burton Dassett Hill, I have previously described.

The steep slopes of the terraces are often covered with gorse, whilst the flat tops are usually clear. Although some allowance must be made for the work of the husbandman in clearing the land, the loose drier soil of the bank slope seems to favour better the growth of the gorse.

It is not possible here to attempt any description of the terraced slopes of the chalk hills, nor of the lynchets of Dorsetshire. Reasons like those I have brought forward will no doubt prove their similar method of formation. The sandy marls of the Dorsetshire Inferior Oolite have, in fact, a composition approaching that of the marls of the Middle Lias of the Midlands. The *lynches* of Oxfordshire, high and overhanging banks of streams, occur generally along the line of the micaceous marls.

The sand of an hourglass will, in its running, make miniature ridges, but in the few other simple experiments I have tried I have not been successful in making them artificially.

The section of a terraced hill in the accompanying figure may help us to understand better how the continuous work of the every-day natural forces moulds and shapes hill and vale to make the soft scenery of the Midlands.

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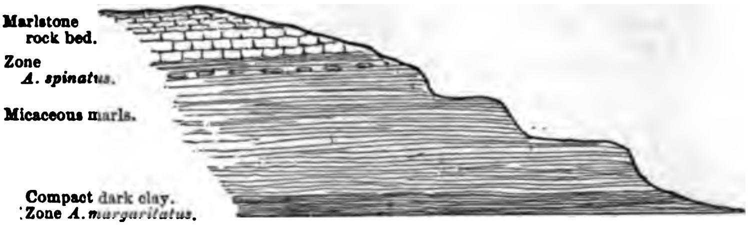
[1] In an old ward map belonging to James Stockton, Esq., of Banbury, I have noticed the words 'mere' or 'mare' affixed to the names of lands. It would seem as if it better applied to water spread over ill-drained land rather than in the other sense indicating a boundary.



HILL SECTION TO SHOW THE FORMATION OF THE TERRACED SLOPES.

Faults.—Where there are terraced banks I have been able to trace in nearly every instance also the presence of a contiguous fault. At Gredenton Hall, near Fenny Compton, Warwickshire, a small exposure shows the fault at the south-west end where the marlstone rock has slipped down to the level of the marls, and, as it were, squeezed the banks out of the flanks of the hill. The faults are probably part of the step-faulting common to every hillside. Here and there the slope of the line of terrace is in the opposite direction to the dip of the vale.

The cols and coombs of our minor vales are full of varying examples. The main vale (the Cherwell) is of low grade and is void of examples. The banks of the minor vales (where there is uniformity of stratigraphical conditions, as over the area covered by the banks) have a grade varying in steepness in proportion to approach to the source. It is to the region bounded by the Edge Hill escarpment and the Burton Dassett Hills that these notes more particularly apply.

The steps of the meadow bank, the steps of the mountain from summit to plain, parallel roads, cirques, corries, and the like, have a common origin downslide, the movement of rock along lines of drainage towards the lines 'of slower disintegration. Whether we study meadow banks or mountains, uniformity of plan shows through the whole.

NOTE.—See article in the GEOLOGICAL MAGAZINE, 1869, Vol. VI, pp. 537–42, by G. Poulett Scrope, F.R.S.

IV.—NOTE ON A SECTION OF THE PLEISTOCENE RUBBLE DRIFT NEAR PORTSLADE, SUSSEX.

By S. HAZZLEDINE WARREN.

THE interest of this section lies in its bearing on the theoretical considerations relative to the causes that produced the extensive deposits of Rubble Drift in the South of England.

The old sea cliff, which is now protected from the sea by a shingle-bank some little distance away, was, at the time of my visit, in November, 1896, being cut back for the extraction of flints and sand. The following section was noted, the thicknesses given being only approximate:—

4.	Surface soil	1 ft.
3.	Dark-coloured stony clay descending into pipes	6 in. to 3 ft. or more.
2.	Contorted chalky loam, a large proportion of its mass being composed of flints, often broken, said to yield mammalian remains at the base	10 ft. to 12 ft.
1.	Light-coloured sand, red in the upper part, with layers of well-rolled flint pebbles, and many concretionary nodules, which are sometimes tabular. Marine Mollusca and Balanidæ fairly abundant: *Mytilus edulis* in the pebbly layers, *Natica*, etc., in the sand	seen to 9 ft.

No. 1 is the well-known Raised Beach, in which the shells, particularly *M. edulis*, have frequently their colour preserved.

No. 2 is locally known as "Coombe Rock." It is the "Rubble Drift" of Prestwich (1892), and the "Elephant Bed" of Mantell (1822).

No. 3 much resembles the Trail (Fisher, 1866) of the valleys of the Thames, Lea, etc., but could not safely be correlated with that deposit. It has more probably been formed in place by solution of the calcareous matter out of No. 2.

The Rubble Drift here presents rather the appearance of ice having been concerned in its formation; although, as the Raised Beach is undisturbed, this could not have been in strong force. The contortions may very possibly have been produced by the melting of intercalated blocks of ice. I am by no means sure, however, that a moving mass of semi-fluid mud and stones would not assume contortions similar to those presented in this exposure, without the aid of ice, in a manner analogous to the knotty twists and tortuous waving lines so frequently seen in vitreous (and, of course, devitrified) lava-flows.

On Sir Joseph Prestwich's theory (Q.J.G.S., vol. xlviii, p. 271) of this drift having been formed by submarine currents produced by the rising of the land after a short dip in the sea, these contortions are inexplicable. And, in addition, there is no direct evidence of such a submergence; indeed, the absence of marine shells is strong negative evidence against it. Neither is there any particular *a priori* probability of such an event.

That of Mr. Clement Reid (Q.J.G.S., vol. xliii, p. 364) I am inclined to accept as the best explanation yet suggested. There is no indication of glaciation, in the full sense of the term, south of the Thames. But the ground must have been deeply frozen during the winter. The summer thaw and rains would cause extensive floods; for, the chalk being frozen, and therefore impermeable, all the rain and water from the melted snow would sweep over the surface of the ground, and carry along large quantities of chalk rubble and flints. Many of the flints would become broken and battered, but not much water-worn, which is the appearance they actually present in the Rubble Drift.

This section is admirably interpreted by this theory. For whether the contortions were produced by the melting of contained blocks of ice or masses of frozen snow, or whether by the internal movements of a semi-fluid mass of mud and stones, or were referable to both causes, in part, it would be equally in accordance therewith. They are, in either case, a stumblingblock to that of Sir Joseph Prestwich.

The Palæolithic implements, however, that have been found in the Rubble Drift, present rather a difficulty. For such implements usually appear to be of later date than the Chalky Boulder-clay. And, if this theory be correct, one would suppose that the Rubble Drift should have been formed contemporaneously with that deposit, if not previously. I hardly think it can be the equivalent of the Trail, as held by Mr. J. Allen Brown (Journ. Anthrop. Inst., vol. xxii, p. 66), because, in that case, a strong semi-glacial deposit would be the equivalent of a comparatively weak one situated farther north, which scarcely seems probable.

But this is a question of probabilities, not of facts. Mr. Clement Reid's theory not only gives a satisfactory explanation of the origin of the Rubble Drift, but also refers the formation of the dry chalk valleys to the same cause. This speaks volumes in its favour, for the value of a scientific theory depends upon the range of phenomena that it co-ordinates.

V.—NOTES ON THE AGE AND STRUCTURE OF THE GNEISSOSE-GRANITE OF THE HIMALAYAS WITH REFERENCE TO MR. MIDDLEMISS'S MEMOIR ON THE GEOLOGY OF HAZARA.

By LIEUT.-GENERAL C. A. McMAHON, V.P.G.S.

I AM indebted to Mr. C. S. Middlemiss, Superintendent of the Geological Survey of India, for a copy of his Memoir on the Geology of Hazara and the Black Mountain recently published.[1] Mr. Middlemiss has embodied in his Memoir the results of an unfinished survey by Mr. A. B. Wynne, late of the Geological Survey of India, and by linking these with his own more recent work, has given us an interesting and valuable Memoir on the Geology of the Himalayan district of Hazara.

As there seems to be no prospect of a systematic survey of the whole Himalayas being undertaken during the lifetime of the present generation, the geological student has to content himself with such information as observers are able to glean during visits of limited duration to these mountains. The Government of India doubtless considers the search for coal, and other economical products, as more pressing than investigations having the elucidation of theoretical problems for their aim; hence the members of the Geological Survey are only able to devote limited periods during occasional visits to the Himalayas to pure geology.

Mr. Middlemiss's Memoir contains a mass of well-digested facts, and he draws many inferences from those facts with which I cordially agree. There are some theoretical questions, however, which have an important bearing on the history of the Himalayas on which we differ; and I propose, for the sake of brevity, to limit myself in this paper to the discussion of these questions.

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[1] Memoirs of the Geological Survey of India, vol. xxvii.

The first point is the *age* to be assigned to the intrusion of the gneissose-granite.

Mr. Middlemiss discusses, among other things, the origin of the granite: namely, whether it was an ancient gneiss (p. 273); a metamorphosed sedimentary rock (p. 275); or a true granite. I do not propose to go into these questions, because Mr. Middlemiss freely admits that, whatever its origin and mode of birth may have been, it behaved as a granite when it intruded into the Himalayan strata. If a rock be mineralogically and functionally a granite, I am not disposed to make curious inquiries of Vulcan as to whether it has a bar sinister on its escutcheon. If it behaves like a granite and a gentleman after its introduction into polite geological society, I am satisfied.

It is not alleged that the foliation to be observed in the granite is due to the original taint in its birth; on the contrary, another and post-genital cause is assigned. This discussion as to its origin is therefore, as far as the geology of the Himalayas is concerned, a purely academic one. Mr. Middlemiss holds that the granite—

1. "Must have been so heated as to get at least into a plastic state in which it was capable of considerable movement under pressure along lines of least resistance" (p. 273); and was capable of "in part consuming" the strata into which it was intruded (p. 274).
2. That it functionally acted as an igneous intrusive rock (pp. 274, 276).
3. That it sent off dykes, sills, and intrusive veins into the adjoining rocks—instance, figs. 1, 2, 4, 44, 45, 51, and 52, and pp. 61, 63, and 64.
4. That it is "always surrounded by a concentric zone of well-defined extra metamorphism" (p. 276).
5. That it contains numbers of "included fragments of schists and quartzite" (p. 63).

As the gneissose-granite was intruded into the Himalayan strata long subsequent to their deposition, and as it uniformly behaved as an igneous rock, I think we may content ourselves with calling it a granite and pass on to consider the actual date of its intrusion. Mr. Middlemiss considers that its age "must be at least Pre-Triassic, whilst it is possible that it may be earlier than Carboniferous, e.g. Silurian" (p. 278). The reasons which the author assigns for this opinion, briefly stated, are as follows:—

1. The absence of metamorphism in Tertiary beds (p. 137); and the non-occurrence of granite in Tertiary strata (p. 277, footnote).
2. The occurrence of Murree beds and Nummulitic limestone in direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism (p. 135).
3. (*a*) The non-occurrence of intrusive granite in the "Tanols."
   (*b*) The opinion of the author that the granite is older than the "Tanols."
   (*c*) The probability that the "Tanols" derived their materials from the granite.

(*a*) (*b*) (*c*) will be found at p. 239 (6).

4. The probability that the "volcanic rocks of Kashmir (the amygdaloids) of about Silurian age are subaerial representatives of the granitic cores" (p. 278).

5. The author also relies on the following points:—

(*a*) The Trias limestone in Hazara is unmetamorphosed (p. 277).

(*b*) The Infra-Trias of Hazara is metamorphosed in a minor degree compared with the slate series (p. 277).

(*c*) Much, if not all, of the metamorphism of the Infra-Trias is attributed to the invasion of basic dykes (p. 277).

I propose to take the above five points seriatim.

1. *The absence of metamorphism and the non-occurrence of granite in Tertiary beds.*—I do not see how this fact proves that the granite is of Pre-Tertiary age. It would only prove, at most, that in the sections in which Tertiary beds occur the granite did not rise as high as the Tertiaries. Mr. Middlemiss remarks (p. 274) that the granite, "if conceded a granite origin," "was formed as great laccolites, *deep down below the surface of the earth*" (the italics are mine), "under such enormous pressure of the superincumbent rock that an irruptive function was generally denied it." If so, how could these deep-seated laccolites be expected to appear as eruptive rocks among beds as high up in the geological series as the Tertiaries?

The appearance of the granite, according to the author, is limited to his crystalline and metamorphic zone, which in Hazara was the first to rise, rose the highest, and was denuded the most (pp. 261, 265). The present boundaries of the Sewalik and Nahan Tertiary rocks on the flanks of the Himalayas are also the limits of their original deposition.[1] Mr. Medlicott found that "the Himalayan mountain area was defined before the deposition of the Sabathu nummulitic rocks,"[2] and I do not gather from Mr. Middlemiss's Memoir that he challenges this position for the rest of the Himalayas. Indeed, he tells us (Memoirs G.S.I., xxiv, 122): "I think we are justified in denying that they [the Eocene nummulitic rocks] ever existed over those higher tracts of the outer and central Himalaya where never an outlier of them has been detected." If Tertiary rocks were never deposited over the zone invaded by the granite, how does its non-appearance in Tertiary strata, and the absence of contact-metamorphism in Tertiary beds, throw light on the age of the granite? Manifestly the points relied on do not prove the author's contention.

The second piece of evidence is the fact that Murree (Lower Sewalik) beds and Nummulitic limestones rest in direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism (p. 135).

The author relies on the evidence afforded by the Laichi Khun section (see footnote to p. 277) to refute my theory that the granite is of Tertiary age. "After what has been said," he writes, "concerning the Laichi Khun section, its Tertiary age is plainly impossible." In view of this contention it becomes necessary to examine the Laichi Khun facts in some little detail.

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[1] Manual G.I., 2nd edition, p. 468. Memoirs G.S.I., Middlemiss, xxiv, pp. 120–2; xxvi, pp. 266–8.

[2] Memoirs G.S.I., iii, p. 174.

The description of the Laichi Khun and Hubeeboollah section begins at p. 129 in the Memoir under consideration, and the argument based on the facts is stated at p. 135 as follows:—"I must now invite attention to one of the most important deductions that may be drawn from the Gurhee-Hubeeboollah sections. In a previous memoir (Physical Geology of the Sub-Himalaya of Kumaun and Garwall[1]) I remarked on the absence of metamorphism in the Upper Tertiaries and Nummulitics in the vicinity of the schistose and granite area of Kalogarhi (also called Kalandanda, and latterly Lansdowne) as offering a not very rigid proof that the Tertiaries at least were deposited later than the date of the general metamorphism of the Himalaya by the intrusion of the gneissose-granite."

I objected to this evidence in a footnote to my Presidential Address,[2] on the ground that the granite appeared to be five miles distant from the Tertiaries; and Mr. Middlemiss seems to have felt the force of it, for he now says that the "proof" is not "very rigid," and proceeds as follows:—

"We have here before us in this corner of the mountains a much more satisfactory proof, inasmuch as the Murree beds, the Nummulitic limestone, together with the sandstone beds at the base, lie all in direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism. They form outliers capping the tops of the hills, whilst the schistose slates form the base of the same hill range."

The author does not tell us what series the "thin-bedded rocks exhibiting distinct metamorphism" belong to; but I presume, from his description of the section between Srikote and Laichi Khun (the section referred to, pp. 131, 132), and from the geological map which accompanies the Memoir, that these beds belong to the Infra-Trias. Notwithstanding the use of the phrase "normal superposition," the beds can hardly be referred to the Cretaceous, Jurassic, or Triassic series, as that would be opposed to the author's argument that the contact-metamorphism of the granite goes no higher, at most, than the Infra-Trias. Neither the map nor the detailed description of this section show the presence of beds of the "Tanol" or of the "Slate" series between Hubeeboollah and Laichi Khun; and as it would not get rid of the difficulty, but, on the contrary, increase it, to refer the thin-bedded rocks to either of these series, I am forced to the conclusion that the metamorphosed beds belong to the author's Infra-Trias series. But, even so, it is clear that a tremendous fault, or a great unconformity, intervenes between the Nummulitic and Infra-Triassic beds. The author writes at p. 131: "In this section, which shows no signs of faulting above the Infra-Trias, there is neither Trias, Jura, nor Cretaceous represented.

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[1] Memoirs G.S.I., xxiv, pt. 2.
[2] Proc. Geol. Assoc., vol. xiv, p. 93.

. . . . The absence of these formations, coupled with the conglomeratic character of the base of the sandstones, and the inclusion among it of an angular clastic breccia so plainly remade from the *in situ* brecciated cherty bands of the Infra-Trias, argue an unconformity at this spot." Just so; but what then becomes of the author's argument at pages 135 and 277 (footnote), that the presence of unaltered Tertiary rocks resting in "direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism" shows that the Tertiaries were deposited later than the metamorphism of the strata, and makes the Tertiary age of the granite "plainly impossible"?

If a vast lapse in geological time exists between the metamorphosed Infra-Trias and the unmetamorphosed Tertiaries; and if great thicknesses of beds belonging to the Triassic, the Jurassic, and Cretaceous periods (or some of them) have been removed by erosion, how are we to say what agent caused the metamorphism of the Infra-Triassic strata on which the Tertiary beds now rest?

We have positively no ground for assuming that the metamorphosing agent in the case of the Laichi Khun beds was granite. Granite does not apparently occur in any part of this section, and the author tells us at page 277 that the metamorphism exhibited by the Infra-Trias "may be attributed to the eruption of basic dykes." The metamorphism of the schistose beds under discussion may have been due to regional metamorphism, to dynamic causes, or to the intrusion of basic igneous rocks, for all we know. What, then, does this section prove regarding the age of the granite?

If, for the sake of argument, we were to assume, without a tittle of evidence to support the assumption, that the metamorphism of the thin-bedded rocks was due to the contact action of granite, what would it prove as to the age of the granite? The fact, it seems to me, would only prove that the granite did not, in this particular section, rise as high as the Tertiary beds; it would not prove that it was Pre-Tertiary in age. The author tells us (p. 274) that the granite "was formed as great laccolites, deep down below the surface of the earth, under such enormous pressure of the superincumbent rocks that an eruptive function was denied it." That being so, the section relied on, even on the assumption that the metamorphism was caused by granite, would prove no more than that the granite was kept down by the "enormous pressure" of the cover, and did not rise as high as the Tertiary beds. It would not prove that the granite was intruded into the strata where it is now found before the Tertiary beds were deposited at a great height above them.

The author's third argument (ante) may be divided into three subheads—

(*a*) The author has observed no instance of the intrusion of the granite into the "Tanols."

(*b*) In the author's opinion the "Tanols" are younger than the granite.

(*c*) In all probability the "Tanols" have derived their material from the granite.

The "Tanols" are arenaceous deposits (p. 56); they are sometimes so highly metamorphosed "that there is no longer any direct evidence from individual samples and sections that the rocks are true representatives of what were originally sedimentary deposits" (p. 57). The author considers that they largely represent (pp. 231, 232) metamorphosed sandstones and quartzites of the Infra-Trias; their relative position among the formations in the Hazara district has not been satisfactorily determined (p. 237). The author thinks that possibly the Boileau Gunge quartzites (Krol quartzites) at Simla are of the same age as the Tanols (p. 239), and that the Gondwana formation of Peninsular India is not impossibly represented in part by the Tanols.

The reference to Simla rocks is interesting. In reading Mr. Middlemiss's memoir I frequently came across descriptions of rocks that brought the Blaini, the Krol, and the Infra-Krol series of the Simla area vividly before my eyes. The correlation of the Infra-Triassic conglomerate with the Blaini conglomerate was evidently present to the author's mind, for he says that the supposition that the Infra-Triassic boulder-bed is "homotaxial with the Salt-Range Boulder-bed" is fairly reasonable; and he goes on to state that "there is little doubt that the Panjab conglomerate of Kashmir is nothing but a continuation of the same deposit"; namely, the conglomerate of the Salt Range. The author also speaks with approval of Mr. Lydekker's correlation of the conglomerate of Kashmir with the Blaini conglomerate of the Simla region, and writes (p. 22): "I am disposed to believe in the connection between the Hazara Infra-Trias conglomerate and the Blaini conglomerate."[1]

That being so, a doubt arises whether the "graphitic schists streaking the hillsides black," referred to at p. 250 and elsewhere (pp. 245, 247, and 252), associated with limestones, are not metamorphosed representatives of the "black crush" (Infra-Krol) rock of the Simla area. A further doubt arises whether the "arenaceous beds" referred to at p. 255 and in fig. 52, containing fine interpenetrations of the granite," are not really metamorphosed Tanol (Krol quartzite) arenaceous beds. Also whether the crystalline limestone at Sauvai, associated with the graphitic schists (p. 250), is not really metamorphosed Infra-Trias. If so, the gneissose-granite crops up close to the Sauvai crystalline limestone and is intrusive in the arenaceous beds which I suggest are of Krol quartzite age.

Oldham has shown that Infra-Krol beds are invaded and metamorphosed by granite in the Satlej Valley[2]; and in the Simla area I have identified thick beds of calcareous chloritic schists as highly altered Krol limestone[3]; and I think it highly probable that the arenaceous beds, graphitic schists, and crystalline limestones, described by the author as occurring in his metamorphic zone, are highly metamorphosed equivalents of the Krol and Infra-Krol rocks of the Simla area.

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[1] See also author's remarks at p. 247.

[2] Records G.S.I., xxi, p. 149.

[3] Records G.S.I., x, p. 212.

If this surmise should prove correct, the appearance of the granite could not be dated *earlier* than the Carboniferous period, and it might be much younger.

As regards the subheads (*b*) and (*c*) ante: (*b*) is a mere expression of opinion and calls for no comment; while I need only say with reference to (*c*) that the only evidence given in proof of the author's contention that the Tanols were derived from the gneissose-granite is that the Tanol beds are composed of coarse-grained quartzo-felspathic material (p. 239). So also is the Torridonian Sandstone of Scotland! The fact relied on proves no more than that the Tanols were derived from a granite. I and other writers have heretofore held that an ancient granite, or gneiss, was suffering erosion in, or adjoining, the Himalayan region in Palæozoic times. This theory is highly probable in itself, and has cogent facts to support it. The author's view that this ancient granite was the gneissose-granite itself is not proved by the fact that all the granite the author has himself seen is of one kind. My own experience led to a different conclusion—a conclusion adopted by Strachey and other observers. The contention that *all* the granite of the Himalayas is of one age has yet to be proved.

The author's fourth point is the probability that "the volcanic rocks of Kashmir (the amygdaloids) of about Silurian age are subærial representatives of the granitic cores" (p. 278).

What this opinion is based on I do not know. At present the only petrographic determination of the Kashmir traps with which I am acquainted is the reference to them by Mr. Lydekker,[1] based on a note by myself on specimens collected by him. These samples, however, were so altered by aqueous agencies that a determination of the rock species, I stated, would, if made, "be to a large extent guesswork." Subsequently I made a rather complete collection of the traps on the Chamba border of Bhadarwah, a subdivision of the territory under the Raja of Kashmir, which was published in 1885.[2] These traps consisted of altered basalts, basalt porphyry, andesites, felsites, and volcanic ash.

Mr. Lydekker, in his memoir above referred to, tells us that one of his specimens contained 54·1 and another 62·9 per cent. of silica. The Kashmir specimens, therefore, would appear to be altered lavas belonging to the basic and intermediate classes. So far as the published evidence goes, there seem to be no grounds for considering the lavas of the Kashmir Valley to be the surface representatives of the gneissose-granite of the Himalayas, and the idea of determining the age of the granite by the age of the Kashmir lavas is, to say the least, premature.

Lastly, the author (p. 277) relies on the following facts:—

(*a*) The Trias limestone in Hazara is unmetamorphosed.

(*b*) The Infra-Trias of Hazara is metamorphosed in a "minor degree" as compared with the "Slate" series.

(*c*) The metamorphism of the Infra-Trias is attributed to the contact action of basic dykes.

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[1] Memoirs G.S.I., xx (1883), p. 218.

[2] Records G.S.I., xviii, p. 93.

These facts are interesting as far as they go; but they fall far short of proving that the intrusion of the granite is Pre-Triassic, or Pre-Infra-Triassic.

As already stated (loc. cit.), Oldham has shown that the gneissose-granite is intrusive in Infra-Krol rocks in the Satlej Valley, which cannot be older than Carboniferous, for the Infra-Krol beds rest on the Blaini group, for which a Carboniferous age has been assigned (compare Mr. Middlemiss's Memoir, pp. 129, 133, 135, and 206).

Mr. Lydekker's description of the rocks in the Shigar and Bráldu regions[1] shows that the Trias and "gneiss" are constantly associated together, and a future detailed examination of that and other regions in the Himalayas, now that we know the igneous character of the gneissose-granite, may show that it is intrusive in rocks of later age than the Carboniferous period. As long as the granite was supposed to be a gneiss—namely, a converted sedimentary rock—no one took notice of contact-metamorphism, for that was supposed to be a part of the general metamorphism of which a gneissic structure was the extreme expression.

Mr. Griesbach has shown that granite traverses and alters rocks of Permo-Carboniferous,[2] Cretaceous,[3] and Eocene[4] ages in Afghanistan. Whether these hornblendic granites (which appear to be either gneissic in part, or to be associated with gneisses) are related to the gneissose-granite of the Himalayas, I do not pretend to say; but, at all events, it is clear that the intrusion of granite took place in Afghanistan, the mountains of which seem genetically related to the Himalayas, down to Eocene times. The evidence at present collected does not, I think, require us to believe that the history of the Himalayas, especially as regards the age of its granite, presents essentially different features from that of the Hindu Kush. If we have Eocene granite in the latter, why not in the Himalayas?

Even if, in the Himalayas, no outcrop of granite should hereafter be found in strata of later age than Infra-Triassic or Triassic, I should not hold that this fact, taken alone, proves that the age of the granitic intrusion is Pre-Triassic. I should not expect to find granite, as granite, in rocks of Miocene or Pliocene age. I should expect to find the representative of the granite in such rocks less holocrystalline in structure than a true granite and more like a porphyrite, or porphyry. In my original description of the Dalhousie rock I mentioned that in places the matrix became so fine-grained that the rock assumed "the outward aspect of a felspar porphyry." This aspect, and the "crypto-crystalline" structure of the mica described in my original papers, and in my address as President of the Geologists Association (Proc. Geol. Assoc., vol. xiv, p. 245), are incompatible with the supposition that the final consolidation of the rock took place under plutonic conditions, but indicate a more rapid cooling than is consistent with those conditions. These structures, it seems to me, would not now be visible if the rock had taken long ages to cool at a great depth below the surface, with all the rocks later than those of Carboniferous age piled up on the top of it.

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[1] Records G.S.I., xiv (1881).

[2] Records G.S.I., xix, p. 241.

[3] Memoirs G.S.I., xviii, p. 348. Records G.S.I., xix, pp. 64, 242; xx, pp. 22, 23.

[4] Records, xx, pp. 102, 103.

I will now pass on to offer a few words of explanation regarding the following observation made by Mr. Middlemiss in the Memoir under consideration. He writes at p. 274 as follows: "Probably the first idea of many people after superficially studying the Himalaya would be to regard the great crystalline axis as having been the cause of the upheaval of the mountain mass, the prime mover, which bursting through the other rocks wedged them apart and folded and contorted them." A footnote to this passage refers to some remarks of mine in my Presidential Address already alluded to.

This reference to my views appears to imply a misunderstanding of their scope. I said that "The contortion, compression, and upheaval which marked the earth movements that set in at the close of the Eocene period, were connected with the intrusion of the gneissose-granite." I said "connected with" advisedly. I did not assert that the granite was the *sole* cause of the contortion, compression, and upheaval, and I did not assert that the "earth movements" were caused by the rise of the granite. I did not for a moment lose sight of the fact that tangential pressure (apart from the rise of the granite) was a potent factor to be taken into consideration; and I spoke (Proc. Geol. Assoc., xiv, p. 289) of the granite being "forced, under conditions of great *lateral* and upward pressure, between the jaws of faults." I remarked that the granite "runs, on the whole, with the strike of the sedimentary rocks, and its outcrop seems to be directly connected with the wrinkling of the strata and the formation of overthrust faults" (loc. cit., p. 93); and again, that the granite was "implicated in the folding in a way to suggest *intrusion* along overthrust faults." These overthrust faults were, I presumed, caused by tangential pressure. I wished to point out that the intrusion of beds of granite—in some cases twelve miles thick, along the whole line of the Himalayas—must have contributed greatly to the compression of the strata. I thought that it would be sufficiently obvious that the compression due to the intrusion of the granite *followed*, and did not precede the formation of the faults, fissures, and planes of weakness, which enabled the granite to penetrate the sedimentary strata. When I spoke of intrusion along overthrust faults I thought the reader would understand that the faults must be formed before the granite was forced into them; and consequently I did not think it necessary to explain that the granite was not the cause of the faulting.

As regards the question of elevation, Mr. Middlemiss remarks at p. 273:—"So far as Hazara and such parts of the higher and lower Himalaya that I have seen are concerned, the rock, if originally a gneiss, must have been so heated as to get at least into a plastic state in which it was capable of considerable movement under pressure along lines of least resistance. On the other hand, if the rock is really a granite all through, that is to say, the product of a molten magma drawn from some unknown underground reservoir, then its activities as an intrusive rock have been kept well under control."

Whichever of the two views stated by the author be adopted, it is clear that there must have been a reservoir of molten or semi-molten rock at the root of the Himalayas sufficiently capacious to have supplied the enormous masses of gneissose-granite now to be found along the whole length of these mountains, for it is admitted that the granite came into place as an intruder, and it is not suggested that sedimentary rocks were heated up and converted into granite *in situ*. The author speaks of the "granitic foundations out of which the Himalaya were ultimately to rise" (p. 275)—that, by the way, sounds rather like my own view which the author contests—and he contrasts them with the "gneissic foundations of the peninsula of India" (p. 275); and the author remarks with reference to the theory of those who assert the Archæan age of the gneissose-granite, "even they must admit a pretty thorough mixing of the material by some agency before it quietly found its way in an intrusive capacity among the ancient sedimentary rocks" (p. 276).

The author's views, then, involve the supposition that immediately preceding the intrusion of the granite there was a reservoir of molten or semi-molten rock forming "the granitic foundations out of which the Himalaya were ultimately to rise." That being so, what, I would ask, would be the result of powerful tangential pressure applied to the sides of this reservoir? Would not the granite "rise along the line of least resistance"? This rise of the granite, the author tells us, took place "under such enormous pressure of the superincumbent rocks that an eruptive function was generally denied it" (p. 274), and "it was formed as great laccolites." That being so, would not granite moved upwards with sufficient force to overcome the "enormous pressure" that tried in vain to keep it down, have elevated the rocky cover? I think such elevation would, under the conditions supposed, be inevitable, and that I was therefore fully justified in stating that "the contortion, compression, and upheaval of the Himalayas were connected with the intrusion of the gneissose-granite."

(*To be continued.*)

NOTICES OF MEMOIRS.

I.—A New Fossil Cycad from the Isle of Portland.

(PLATES XIII AND XIV.)

AN example of a Jurassic Cycadean stem of exceptional interest has lately been added to the Fossil Plant Gallery of the British Museum. The specimen is described in detail by Mr. A. C. Seward in the Quarterly Journal of the Geological Society for February of this year.

Geologists have long been familiar with the short and thick Cycadean stems described by Buckland and others from the Purbeck beds of Portland, but the recently acquired fossil differs in many respects from the shorter stems or "crows' nests" hitherto recorded as the common type of Cycads from this locality. The specimen was found in one of Mr. Barnes' quarries, and, as shown in Fig. 1, it was obtained from a bed of shaly clay 17 feet higher in the Purbeck series than the Great Dirt-bed which has yielded most of the Portland plants. Mr. A. M. Wallis, a local guide and quarryman, who at once recognized the value of the specimen, saved it from destruction, and Dr. Woodward was fortunate enough to obtain the magnificent stem for the National Collection.

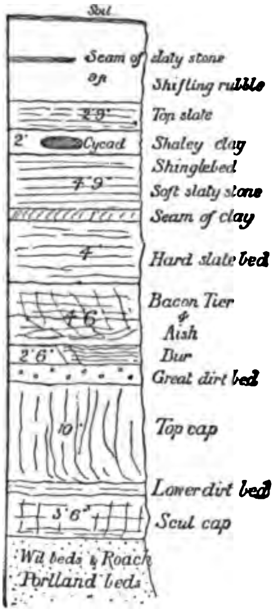
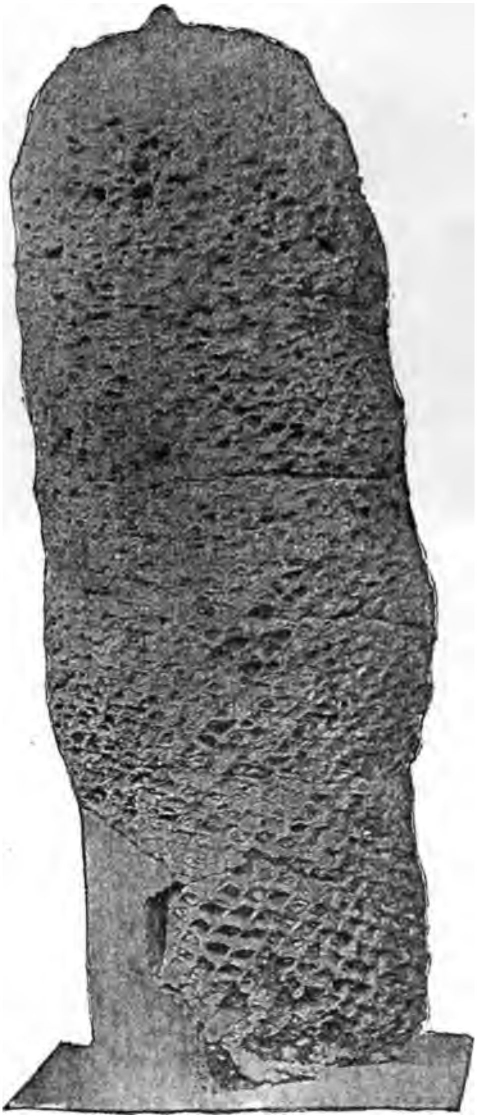


FIG. 1.—Section of the quarry on Portland in which the Cycadean Stem was discovered by Mr. A. M. Wallis.

The trunk is shown in its natural position in Plate XIII, which is reproduced from a photograph taken by Mr. Gepp of the British Museum. The total height is nearly four feet (1 m. 18·5 cm.), and the girth at the broadest part about 1 m. 7 cm. The surface features are best seen close to the base (Plate XIV, Fig. 2); there is a prominent network with meshes arranged in regular rows and passing spirally round the stem. Each mesh marks the position of a leaf-stalk base; the substance of the petiole has disappeared in most cases and left a cavity; the reticulum consists of ridges of silicified tissue, which existed between the individual petioles. In the living plant numerous scaly or laminar appendages were attached to the surface of the petiole base, and these formed a kind of loose packing between the fronds. The chaffy scales or paleæ on the leaf-stalks of many recent ferns are almost identical structures, and among existing Cycads somewhat similar appendages are occasionally met with. The mineralizing solution was apparently absorbed more readily by the interpetiolar tissue than by the less porous petioles; the former was therefore more frequently preserved, and in a better condition than the latter.

At the top of the stem an apical bud has been clearly preserved. It is very unusual to find fossil Cycadean stems in which the apical portion has been left intact. The bud is covered with numerous bud-scales, and at the summit there is a terminal cap, shown in Plate XIV, Fig. 1, as a lighter-coloured patch. In Fig. 2, p. 319, this cap presents the appearance of a mass of numerous fine hairs covering the tips of the linear bud-scales.



n of a new Fossil Cycad, *Cycadeoidea gigantea*, Seward.

Purbeck Beds, I. of Portland. ⅛ nat. size.

FIG. 1.

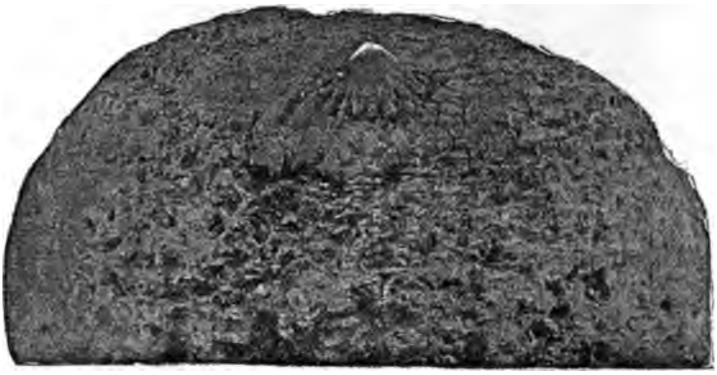
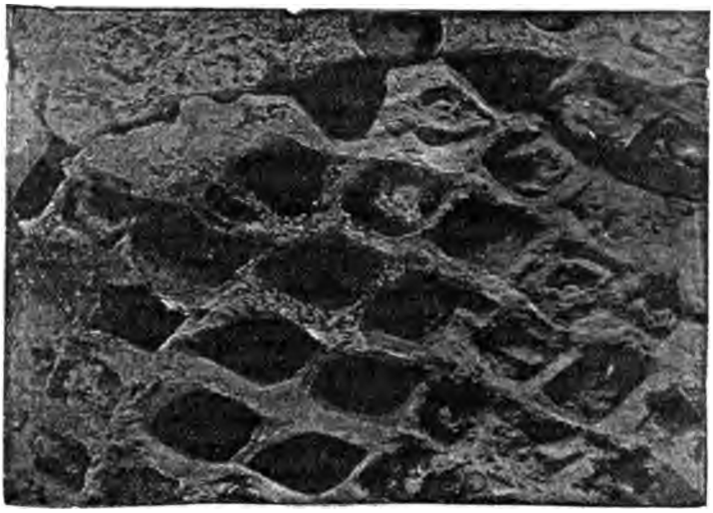


FIG. 2.



FIGS. I AND 2.—*Cycadeoidea gigantea*, Seward.

FIG. 1. The apex of the stem shown in Plate XIII ; about ¼ nat. size.
FIG. 2. Leaf-bases and ramenta from the lower portion of the stem ; about ⅓ nat. size.

The apical bud of recent Cycads is occasionally capped by a mass of loose hairs, and there is the closest possible resemblance between the bud of this Portland stem and that of such a recent Cycad as *Encephalartos Altensteinii*, Lehm., a species well represented in the tropical-house at Kew.

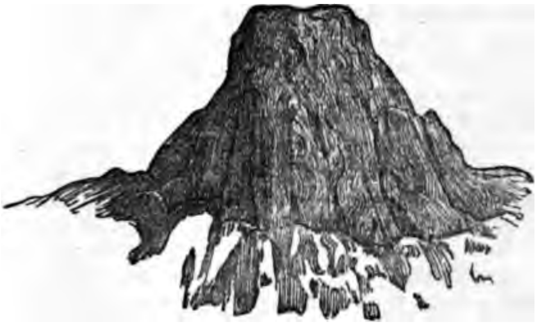


FIG. 2.—Apical bud of *Cycadeoidea gigantea*, Seward.

The material of which the specimen consists is highly siliceous; the central portion exhibits no trace of plant-structure, and is composed of cherty rock, but portions of the more external tissues are in some places exceedingly well preserved. The description of the structure of the petiole bases, and that of the mass of interpetiolar tissue, as given in the more detailed account of the stem, demonstrates a striking similarity between the anatomy of the genus *Bennettites* and that of the new fossil. In the absence of any definite trace of reproductive organs, the Portland stem has been placed in Buckland's genus *Cycadeoidea*, and named *Cycadeoidea gigantea*. As regards the exact affinities of the species, it is impossible, without the evidence of the reproductive organs, to speak with certainty as to its precise position. There is, however, no sufficient reason for regarding the stem as essentially distinct from such a type as is represented by *Bennettites Gibsonianus*, so far as concerns its position in a system of classification.

II.—THE PLEISTOCENE ICE-SHEET IN NORTH AMERICA: ENGLACIAL DRIFT. By W. O. CROSBY.[1]

Probable Early History of the Pleistocene Ice-sheet.

RECENT researches in North America tend to show that an ice-sheet may over a considerable part of a glaciated area have been formed *in situ* by snow accumulation.

A general refrigeration of the climate in mountainous districts, due chiefly perhaps to a marked elevation of the northern part of the continent, had led to the development of glaciers of the Alpine type in the higher valleys. These glaciers became confluent as the cold increased, deploying upon the plains and forming sluggish or stagnant Piedmont glaciers. With progressive refrigeration the annual snowfall finally exceeds the annual melting of the ice. This cumulative snowfall, which mantled alike hills and valleys, and changed slowly through *névé* to glacial ice, must have tended in some measure to check or arrest the motion of the ice which had flowed outward from the mountains. Owing, however, to the forward motion of the Piedmont glaciers, as well as to their termination on tracts where a short time before ablation (or melting) had been in excess of snowfall, they must have terminated somewhat abruptly or with high marginal gradients; and the conditions, therefore, were extremely favourable for their overriding the new and still stationary ice-fields by which they were invested. The overridden tract of ice must slowly acquire the motion of the overriding sheet, and thus in its turn come to override other tracts. In fact, it seems very probable that this process of overriding and absorption would continue almost indefinitely, extending, possibly, over a large part of the glaciated area.

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[1] Abridged from the *Technology Quarterly*, vol. ix, Nos. 2 and 3. (Boston, 1896.)

Assuming a uniform annual snowfall over the area of the sedentary ice-sheet, it is obvious that since its area is gradually extended southward by the progressive climatic refrigeration, while the annual ablation as gradually diminishes northward, its thickness must increase backward from the margin. If, however, as Upham holds, and as certainly seems most probable, the precipitation of snow over the growing ice-sheet was not uniform, but greatest from the first one hundred to two hundred miles inward from the margin, the surface-gradient must have culminated on these peripheral tracts, diminishing gradually backward. This condition would, obviously, favour an early beginning of outward movement or flow in the marginal zone, and tend in an equal degree to retard motion in the central area.

We should hardly be justified in supposing that the great crustal movement which gave us the Ice Age, was steadily progressive, without interruption or reversal, until its final culmination. No doubt the period of the growth and culmination of the ice-sheet, equally with that of its waning and disappearance, was attended with marked climatic oscillation. During these changes the precipitation and ablation would co-operate in accentuating the frontal slope of the ice-sheet. The chief factors in determining movement of the ice-sheet were its thickness and marginal gradient.

The absence from a large part of the glaciated area of mountains or dominant heights of land, requires us to assume that over considerable tracts the sedentary ice-sheet did eventually begin to flow without having experienced the overriding or shearing thrust of the Piedmont ice-fields. The outward movement thus originating in the peripheral tracts during a period of excessive ablation must have extended backward, perhaps until it met the forward thrust of the Piedmont glaciers.

Assuming therefore that the movement of the ice-sheet was inaugurated during a warm period, and that the southern margin the ice has retreated far to the north through ablation, developing bold and aggressive front, it is obvious that the succeeding cold riod must have caused a rapid extension of sedentary ice southard from the front of the moving sheet, and the former would evitably be progressively overridden and absorbed by the latter.

Basal Relations of a Sedentary Ice-sheet.

During the slow accumulation of the ice-sheet, and before it gan to move, the ground beneath it, which must have been turated with water, was probably frozen solid to a considerable pth, possibly nearly, if not quite, to the bottom of the residuary il or other surface detritus; that is, down to the firm rocks. here could have been no original plane of separation or moveent between this frozen soil and the overlying ice-sheet, for the e did not merely rest *on the detritus*, but extended down through it the lower limit of frost.

With increased thickness the ice-sheet became a more and more ficient protection to the ground against the climate of the Ice Age, d the steady efflux of heat from the earth's interior would thus nd to gradually loosen the hold of the frost upon the rocky bstratum.

Observations in the Arctic regions and at higher altitudes show at the ground may become frozen to a depth of several hundred et; but it is well known that glaciated areas are not in general ose of most extreme cold. A humid climate is the first essential, hereas extremely frigid areas, such as the interior of Alaska and rthern Siberia, are relatively dry and non-glaciated. A mean nual temperature a few degrees only below freezing is all that is quired for active glaciation; and as the increasing thickness of sedentary ice-sheet would tend to neutralize the downward netration of frost, we need not suppose that the ground beneath e ice would be frozen to any great depth or far below the detrital yer.

In considering the most probable plane of shearing when the e-sheet begins to move—whether in obedience to its own weight through the overriding thrust of a thicker northern sheet—we ve to consider (1) the ice-sheet proper; (2) the frozen soil beneath to which the ice-sheet is still firmly united; (3) the unfrozen soil sting upon or passing downward into the solid rocks. At the inption of movement the most probable plane of slipping or shearing uld be in the unfrozen soil, the frozen soil and overlying ice ving *en masse*, and the movement being lubricated by the unzen soil, which at most points would be of an argillaceous and astic character.

Observations heretofore made on modern glaciers and ice-sheets e of little value in this connection, because nowhere in the field of servation are realized the conditions that must obtain at the base a sedentary or recently sedentary ice-sheet. The true glaciers or e-rivers of Alpine districts, Greenland, etc., are mere lobes of ice scending under the influence of gravity from the edges of *névé* fields and ice-caps into a climatic zone where permanent ice cannot form; and hence they are moving over unfrozen soil, and the ice is wasting by melting on its under as well as its upper surfaces. The great desideratum is a shaft or boring in the interior of Greenland extending through the entire thickness of the ice-sheet and a hundred feet into its rocky bed. The Greenland studies of Professor Chamberlin show the facility with which ice shears along innumerable lines of débris; it slides over the débris instead of dragging it along, as it would if the débris were firmly frozen into the ice. Granting, however, that the frozen soil would be more rigid and indifferent to gravitative stresses than the clear ice above it, the fact remains that the unfrozen soil at the base is more yielding and plastic than either; and hence, although we may reasonably conceive definite shearing-planes as distributed through a considerable thickness of the ice-sheet, the lowest plane, and the true base of the ice-sheet, will still be at the lower limit of frost.

Rectilinear striæ, often scores of feet in length, are an impossibility unless we conceive the entire mass of the ground-moraine as enclosed in the moving ice. These would be produced during the period of active glaciation when the ground-moraine was very scanty or wholly incorporated with the moving ice. A true ground-moraine between bed-rock and ice, and distinct from both, belongs to the waning stage of the ice sheet and to lobes of ice (glaciers) descending from an ice-cap or *névé* field into a climatic zone where permanent ice cannot form.

All this appears to be quite consistent with the local origin of the greater part of the till or ground-moraine of the Pleistocene ice-sheet, and the well-established fact that the total movement of the ice amounted to hundreds of miles, if we simply suppose that through the granular plasticity of the ice, or a series of shear-planes, the basal, drift-laden layer moves much more slowly than the overlying clear ice.

Absorption of Drift by the Pleistocene Ice-sheet.

As the initial shearing-plane of the ice-sheet is normally at the lower limit of frost, a considerable amount of detritus is englacial from the beginning of the movement of the ice-sheet. When a sedentary ice-sheet is overridden by a Piedmont glacier, or by the readvance of an earlier ice-sheet, the conditions must be favourable for the transfer of drift from the base of the earlier sheet to a somewhat elevated position in the composite sheet which results from the overriding. The overriding sheet will carry with it not only its own englacial drift, but will drag along a part of its ground-moraine or subglacial drift.

It is altogether probable that each important recession of the ice-sheet, and not only the final recession, was characterized by numerous glacial rivers and lakes, and an extensive development of modified drifts in the well-known forms of kames, eskers, deltas, with abrupt northern margins, etc. Such loose deposits would be taken up by the succeeding ice-sheet.

Relatively slight obstructions to the flow of an ice-sheet, whether of solid rock or uncompacted drift, are sufficient to originate sharp overthrust flexures and oblique shear-planes, marked by bands of débris. Thus drift is transferred from a subglacial to an englacial position. It may be concluded that from the summit or crest of nearly every elevation with an abrupt lee-slope, a stream of detritus flowed onward and upward into the ice-sheet during its progress over the land. On the stoss-slope glacial erosion reaches its maximum intensity, as both vertical and flowage pressure co-operate, and much basal detritus is carried forward and from the summits of elevations into the body of the ice, and not down the lee-slopes.

During the period of maximum glaciation a large proportion of drifts may have been dragged down the lee-slopes in the bottom of the ice, and thus striation and polishing of those slopes were produced. Later, when the vertical pressure was less and the velocity of flow greater, the ice hugged the lee-slopes less closely, and the conditions became favourable for the detachment of blocks of rock. Thus ice penetrated the joint-cracks of the rocks and severed blocks, and these were eventually carried away by the moving mass of ice to which they became attached. Indeed, we often find a surface train of angular blocks leading away from the lee-slopes.

During the later stages of the decline of the ice-sheet, basal melting set free considerable volumes of the hitherto englacial drift to form the ground-moraine; and just as the frontal or terminal moraine, also composed of material set free by the melting of the ice, records the cessation of the forward movement or invasion of the ice-sheet, so the basal or ground-moraine records the gradual cessation of the glacial abrasion of the bed-rocks. Generally the ground-moraine rests upon striated surfaces of the rocks, and as it accumulated it was pressed down by the ice to form the typical "hard pan."

Thus, in the earlier and maximum stages of the ice-sheet the basal temperature was below freezing, and the freezing of subglacial waters made and kept the detritus a part of the ice-sheet; in the later stages of the ice-sheet, the basal temperature rose above freezing, and the ice relaxed its hold on the detritus and flowed over it.

Transportation of drift by simple drag is relatively unimportant, if not impossible; the transportation is almost wholly englacial, as insisted by Upham (Bull. Geol. Soc. Amer., vi, 348), but highly differential, being extremely slow in the basal layers and more and more rapid at higher levels. The detritus reaching the highest levels in the ice is carried farthest, not only because of the higher velocity, but also because it remains for a longer time in the ice.

The efficiency of glacial erosion is clearly proved by the fact that over practically the entire glaciated area north of the terminal moraine *all* the preglacial soil and partially decayed rock have been worn away, and there has been an extensive erosion of the hard unweathered rocks. The prevailing colour of the ground-moraine below the sharply defined limit of postglacial oxidation is that of crushed rock, and not of residuary or other preglacial detritus.

Probably no feature of the Greenland glaciers revealed to us by Chamberlin's studies is of greater interest than the beautiful stratification and lamination of the ice. This stratification is due chiefly to the mode of distribution of the drift or rock débris, which forms numerous relatively thin and continuous layers approximately parallel with the bottom of the glacier, and often exhibiting flexures and faults where the ground over which the ice moved was uneven. This englacial drift is ground-moraine absorbed by the ice through flexing and shearing movements. The débris is an element of weakness, and tends to give rise to shearing- and gliding-planes. When we consider how intimate this process of lamination-shearing is, producing in extreme cases as many as twenty distinct layers in an inch, it can hardly be doubted that the englacial rock-fragments, more especially if of small size, must suffer faceting and striation after the manner of the ground-moraine. Thus one supposed distinction between subglacial and englacial drift disappears.

Comparison with Modern Glaciers and Ice-sheets.

That glaciers of the Alpine type are generally free from incorporated drift, other than that derived from lateral and medial moraines through the agency of crevasses, is, no doubt, attributable to the facts that their courses were long since swept relatively bare of detritus, and that in their lower courses they are undergoing basal melting, and hence depositing rather than absorbing drift.

The numerous glaciers descending from the margin of the Greenland ice-cap present two types: (1) the drift-laden glaciers which predominate north of latitude 76°; and (2) the apparently drift-free glaciers to the south. In the former, the drift is strictly a basal feature, rarely rising to greater heights in the ice than 100 to 150 feet, even where the glacier may be a thousand feet or more in thickness. Possibly the northern glaciers are more generally drift-laden because the severe climate tends to prevent basal melting, and a considerable part of it may represent the lower, drift-laden portion of the ice-cap itself. The ice-cap virtually spills over the edge of the plateau through deep V-shaped notches; and the conclusion is unavoidable that a much larger proportion of the upper, clear, and relatively mobile ice will flow down, than of the lower, drift-laden, and relatively immobile ice.

It is the general belief of geologists that if Greenland were divested of its ice-cap it would exhibit continental relief—elevated margins and a depressed interior. Probably very little of the englacial drift rises to a greater height than 500 feet, or possibly 1,000 feet, even when the thickness of the ice is one to two miles. None of the suggested processes of absorption seem competent to diffuse the detritus through a more considerable thickness of the ice.

An important exception to this limitation of the range of englacial drift should be made for the case when a later sedentary ice-sheet is overridden by the readvance of an earlier sheet, the height attained by the englacial drift depending then upon the thickness of the overridden sheet.

Relations of Englacial Drift to Modified Drift.

The modified drift, or washed and stratified gravels, sands, and clays, of glacial origin, forming deltas, terraces, overwash or apron plains, eskers, kames, etc., occur almost wholly in valleys or on lowlands. This drift is due in part (1) to the washing and assorting of the till or ground-moraine by glacial streams during and following the waning and disappearance of the ice-sheet; (2) to the englacial drift through the agency of subglacial streams; and (3) to the melting of the ice and liberation of the englacial drift on its surface where it was washed and assorted by superglacial streams.

The Transportation Argument.

While a small part of the drift of the Pleistocene ice-sheet is far-travelled, the great bulk is of local origin.

Much of the preglacial residuary soil was probably swept away by aqueous erosion during the elevation of the continent and before the formation of the ice-sheet. What was left of it probably became incorporated with the ice-sheet in its earliest stage, and it has ultimately been carried by various agencies, glacial, lacustrine, and fluvial, in large part beyond the limits of the glaciated area. There is little indication of the presence of highly oxidized residuary clay in the till: its matrix is chiefly the finely comminuted and unoxidized detritus.

In its earliest stages the ice-sheet wore away and absorbed a considerable thickness of rotten rock underlying the soil, and during its maximum stage the hard rocks suffered glacial abrasion. On the decline of the ice-sheet, as before mentioned, there was a rending of ledges and detachment of fragments and boulders. These must have been, in general, the last material to be absorbed by the ice-sheet and the first to be deposited by basal melting. Under favourable conditions of flexing and shearing a small part of this material attained a high level in the ice and enjoyed a long glacial transport.

Although the total forward movement of the ice, as indicated by far-travelled erratics, appears to have been as much as five or six hundred miles, and even in some parts of the glaciated area perhaps a thousand miles, a basal slipping of one-twentieth of that distance or less would probably be regarded as sufficient to account for the erosion of the bed-rock surface and the normal distribution of the identifiable fragments. Possibly the total movement of the ice has been overestimated, the more distant erratics having been, perhaps, transported in part by water, and not wholly by the ice-sheet, each marked recession of which provided a series of glacial lakes and rivers along its margin.

It is evident that the entire volume of the drift was englacial during the active erosion of the bed-rock, and that an efficient protection was afforded to glaciated surfaces by even a thin layer of till. Hence drag as a mode of glacial transportation is not to be maintained—a conclusion at which Mr. Upham had previously arrived.

REVIEWS.

I.—THE ANCIENT VOLCANOES OF GREAT BRITAIN. By Sir ARCHIBALD GEIKIE, F.R.S., D.C.L., D.Sc., etc., Director-General of the Geological Survey. Imperial 8vo. In two volumes. Vol. I, pp. xxiv and 477, with seven maps and 175 illustrations. Vol. II, pp. xvi and 492, with 382 illustrations. (London: Macmillan and Co., Ltd., 1897. Price 36*s.* nett.) (First notice.)

THE author tells us that the present work is intended to offer a summary of what has now been ascertained regarding the former volcanoes of the British Isles. The subject, he says, has occupied much of his time and thought all through life. Born among the crags that marked the sites of some of these volcanoes, he was led in his boyhood to interest himself in their structure and history. The fascination which they then exercised has lasted till now, impelling him to make himself acquainted with the volcanic records all over these islands, and to travel into the volcanic regions of Europe and Western America for the purpose of gaining clearer conceptions of the phenomena.

Sir Archibald Geikie has from time to time communicated his researches, during a period of almost forty years, to the Geological Society of London and the Royal Society of Edinburgh. The present work is intended to combine in a general narrative the whole progress of volcanic action from the remotest geological periods down to the time when the latest eruptions ceased.

An opportunity of partially putting this design into execution occurred when, as President of the Geological Society of London, he delivered the Annual Addresses in 1891 and 1892. Within the limits permissible to such essays, it was not possible to present more than a full summary of the subject. "Since that time," writes Sir A. Geikie, "I have continued my researches in the field, especially among the Tertiary volcanic areas, and have now expanded the two Addresses by the incorporation of a large amount of new matter and of portions of my published papers."

The author's labours have culminated in the production of the two handsome volumes which, if they had been written by any less gifted geologist, would still be of the greatest value to the student, by reason of the wealth of maps and illustrations which they contain, chiefly from the writer's own notebooks and sketches, and photographs taken by Colonel Evans and Miss Thom, of Canna, and by Mr. Robert Lunn for the Geological Survey among the volcanic districts of Central Scotland. When to excellence of illustrations, however, is added the facile pen of Sir A. Geikie, the volumes become as attractive from a literary and scientific point of view as the pictures are from an artistic one.

In the opening chapter the author traces the influence of volcanoes and volcanic activity upon the mythology of the early Greeks and Romans, and points out the many opportunities which the dwellers along the basin of the Mediterranean must have had of observing these most striking and startling phenomena of nature.

"When in later centuries the scientific spirit began to displace the popular and mythological interpretation of natural phenomena, the existence of volcanoes and their extraordinary phenomena offered a fruitful field for speculation and conjecture. As men journeyed outwards from the Mediterranean cradle of civilization, they met with volcanic manifestations in many other parts of the world. When they eventually penetrated into the Far East, they encountered volcanoes on a colossal scale and in astonishing abundance. When they had discovered the New World, they learnt that in that hemisphere also 'burning mountains' were numerous and of gigantic dimensions. Gradually it was ascertained that vast lines of volcanic activity encircle the globe. By slow degrees the volcano was recognized to be as normal a part of the mechanism of our planet as the rivers that flow on the terrestrial surface. And now at last men devote themselves to the task of critically watching the operations of volcanoes with as much enthusiasm as they display in the investigation of any other department of nature. They feel that their knowledge of the earth extends to little beyond its mere outer skin, and that the mystery which still hangs over the vast interior of the planet can only, if ever, be dispelled by the patient study of those vents of communication between the interior and the surface.

"If, however, we desire to form some adequate idea of the part which volcanic action has played in the past history of the earth, we should be misled were we to confine our attention to the phenomena of the eruptions of the present day. An attentive examination of any modern volcano will convince us that of some of the most startling features of an eruption no enduring memorial remains. The convulsive earthquakes that accompany a great volcanic paroxysm, unless where they actually fissure the ground, leave little or no trace behind them. Lamentably destructive as they are to human life and property, the havoc which they work is mostly superficial. In a year or two the ruins have been cleared away, the earth-falls have been healed over, the prostrated trees have been removed, and, save in the memories and chronicles of the inhabitants, no record of the catastrophe may survive. The clouds of dust and showers of ashes which destroyed the crops and crushed in the roofs of the houses soon disappear from the air, and the covering which they leave over the surface of a district gradually mingles with the soil. Vegetation eventually regains its place, and the landscape becomes again as smiling as before.

"Even where the materials thrown out from the crater accumulate in much greater mass, where thick deposits of ashes or solid sheets of lava bury the old land-surface, the look of barren desolation, though in some cases it may endure for long centuries, may in others vanish in a few years. The surface-features of the district are altered indeed, but the new topography soon ceases to look new. Another generation of inhabitants loses recollection of the old landmarks, and can hardly realize that what has become so familiar to itself differs so much from what was familiar to its fathers.

"But even when the volcanic covering, thus thrown athwart a wide tract of country, has been concealed under a new growth of soil and vegetation, it still remains a prey to the ceaseless processes of decay and degradation which everywhere affect the surface of the land. No feature of a modern volcano is more impressive than the lesson which it conveys of the reality and potency of this continual waste. The northern slopes of Vesuvius, for example, are trenched with deep ravines, which in the course of centuries have been dug out of the lavas and tuffs of Monte Somma by rain and melted snow. Year by year these chasms are growing deeper and wider, while the ridges between them are becoming narrower. In some cases, indeed, the intervening ridges have been reduced to sharp crests, which are split up and lowered by the unceasing influence of the weather. The slopes of such a volcanic cone have been aptly compared to a half-opened umbrella. It requires little effort of imagination to picture a time, by no means remote in a geological sense, when, unless renovated by the effects of fresh eruptions, the cone will have been so levelled with the surrounding country that the peasants of the future will trail their vines and build their cots over the site of the old volcano, in happy ignorance of what has been the history of the ground beneath their feet.

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"The geologist who undertakes an investigation into the history of volcanic action within the area of the British Isles during past time, with a view to the better comprehension of this department of terrestrial physics, finds himself in a situation of peculiar advantage. Probably no region on the face of the globe is better fitted than these islands to furnish a large and varied body of evidence regarding the progress of volcanic energy in former ages. This special fitness may be traced to four causes: 1st, the remarkable completeness of the geological record in Britain; 2nd, the geographical position of the region on the oceanic border of a continent; 3rd, the singularly ample development to be found there of volcanic rocks belonging to a long succession of geological ages; and 4th, the extent to which this full chronicle of volcanic activity has been laid bare by denudation.

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"There is yet another respect in which the volcanic geology of Britain possesses a special value. Popular imagination has long been prone to see signs of volcanic action in the more prominent rocky features of landscape. A bold crag, a deep and precipitous ravine, a chasm in the side of a mountain, have been unhesitatingly set down as proof of volcanic disturbance. Many a cauldron-shaped recess, like the corries of Scotland or the cwms of Wales, has been cited as an actual crater, with its encircling walls still standing almost complete.

"The relics of former volcanoes in this country furnish ample proofs to dispel these common misconceptions. They show that not a single crater anywhere remains save where it has been buried under lava; that no trace of the original cones has survived, except in a few doubtful cases where they may have been preserved under subsequent accumulations of material; that in the rugged tracts, where volcanic action has been thought to have been most rife, there may be not a vestige of it, while, on the other hand, where the uneducated eye would never suspect the presence of any remnant of volcanic energy, lavas and ashes may abound. We are thus presented with some of the most impressive contrasts in geological history; while, at the same time, this momentous lesson is borne in upon the mind, that the existing inequalities in the configuration of a landscape are generally due far less to the influence of subterranean force than to the action of the superficial agents which are ceaselessly carving the face of the land. Those rocks which from their hardness or structure are best able to withstand that destruction rise into prominence, while the softer material around them is worn away. Volcanic rocks are no exception to this rule, as the geological structure of Britain amply proves."

The first volume treats of the nature and causes of volcanic action, and deals with modern volcanoes. The author next considers ancient volcanoes, and the proofs of their existence to be derived from the nature of the rocks erupted from the interior of the earth. The various types of old volcanoes are described as the Vesuvian type, the plateau or fissure type, the Puy type, and the relative ages to be assigned to these ancient volcanoes. This leads on to the consideration of underground phases of volcanic action, as the intrusive series, vents of eruption, necks, inward dip of rocks towards necks, subterranean movements of the magma, dykes and veins, sills and laccolites, bosses, etc. The influence of volcanic rocks on the scenery of the land. This is followed by chapters on Cambrian and Pre-Cambrian volcanoes, and on the volcanoes of Silurian, Devonian, and Old Red Sandstone time.

We hope next month to take up Volume II, and give a further idea of the nature and extent of this, the latest of Sir A. Geikie's geological and literary ventures; by no means the first, and we trust it may not be the last, which he may contribute to the geology of the Victorian era, a period which covers the best years in the lifetime of our science.

II.—A TEXTBOOK OF GEOLOGY: INTENDED AS AN INTRODUCTION TO THE STUDY OF THE ROCKS AND THEIR CONTENTS. By W. JEROME HARRISON, F.G.S. 8vo; pp. vii, 343. (London: Blackie & Son, 1897.)

EIGHT years ago Mr. Harrison's "Elementary Textbook of Geology" appeared as one of Blackie's Science Textbooks. It has now developed into the above-mentioned work, which, as the author states, is nominally the fourth edition of his little book. A somewhat larger page and a larger type have now been adopted, and the work throughout has been revised. A number of new illustrations have been added, and among these are several very effective scenes reproduced from photographs.

As the author has remarked, while it is true that "geology cannot be learnt from books," so it is equally true it "cannot be learnt *without* books." It is difficult to convey any adequate idea of rocks, especially eruptive rocks, from brief descriptions, and the same is the case with minerals. The student should obtain examples of the commoner rocks and minerals, and personally examine as many as he can of the common and characteristic fossils. He or she will then be able to make good progress with the help given by Mr. Harrison, and it is noteworthy that his book has rendered much service to those who have attended classes connected with the Science and Art Department. Concise and systematic as this text-book is, we can confidently recommend it as an excellent introduction to geology.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 26, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Augite-Diorites with Micropegmatite in Southern India." By Thomas H. Holland, Esq., A.R.C.S., F.G.S., Officiating Superintendent, Geological Survey of India.

This paper deals with a series of basic dykes intersecting the pyroxene-granulites and gneisses of the Madras Presidency, and believed to be of the same age as the lava-flows of the Cuddipah system. These dykes consist essentially of augite (near hedenbergite) and a plagioclase-felspar (near labradorite), between which we find masses of micropegmatitic intergrowths of felspar and quartz, with a micro-miarolitic structure. Around the patches of micropegmatite, chemical changes have frequently taken place in the minerals of the rock. Similar occurrences of micropegmatite in basic rocks have been described by J. A. Phillips and Waller at Penmaenmawr, by Hill and Bonney in Charnwood Forest, by Teall in the Whin Sill and in the Cheviot district, by the last-named author and Harker at Carrock Fell, by Sollas at Carlingford, and by Harker in Skye.

After discussing the chemical constitution of the rock and of its various constituents, and the relation between the micropegmatite and the surrounding minerals, the author points out that three methods for the formation of the micropegmatite may be conceived of:—

(*a*) During the primary consolidation of the magma.

(β) By secondary changes induced in the rock.

(γ) By subsequent intrusion of granophyric material into the augite-plagioclase rock.

In opposition to (γ), the author points out the entire absence of granitic intrusions in the neighbourhood. He regards the absence of all proofs of subaerial hydration and the remarkable freshness of the rocks as precluding the possibility of the micropegmatite having been formed by secondary change. The primary origin of the micropegmatite he believes to be proved by—(1) the crystallographic continuity of its felspar with that of the normal plagioclase of the rock; (2) the mode of occurrence of the micropegmatite, filling in the angles and spaces between the augite and the plagioclase; and (3) its variation in coarseness of grain agreeing with that of the remaining two constituents of the rock.

These augite-diorites with micropegmatite are then compared with the granophyric gabbros of Barnavave, Carlingford, described by Professor Sollas, to which the author maintains that his explanation equally applies. He insists that the separation of the acid and basic materials of a magma, which takes place so frequently on a large scale, equally occurs in the midst of a consolidating mass, and combinations such as that described in the paper will be formed. He insists also on the proofs of close genetic relations between the gabbros and "granophyres," and of their practical contemporaneity in the various districts in which these phenomena have been noticed.

2. "The Laccolites of Cutch and their Relations to the other Igneous Masses of the District." By the Rev. J. F. Blake, M.A., F.G.S.

The author has observed thirty-two domes of various kinds in Cutch, distributed as follows: (i) those connected with the northern islands; (ii) those of Wagir; and (iii) those along the northern edge of the mainland. They are divisible into four classes: (*a*) those which are so elongated on the line joining adjacent ones that they seem to be mere modifications of anticlinals, though the supposed anticline is not really continuous; (*b*) those which lie in a line, but are not elongated in that direction, and often in no other; (*c*) those which are related to a fault, which cuts them in half; and (*d*) those which are not in any particular relation to each other, or to any other stratigraphical feature.

The domes vary in degree of perfection: some are irregular, while some have the strata running in concentric circles, the outer and newer strata dipping away from the inner and older. In no less than ten of the thirty-two domes igneous bosses are found occupying the centre, and these are distributed amongst all of the above classes. The author gives reasons for maintaining that the domes are the results of intrusion of igneous rocks in the form of laccolites, and are not anticlinal folds which have afterwards been affected by cross-folds. The domes are contrasted with igneous peaks which occur in abundance in a different part of the area, usually at a higher horizon of the strata and at a higher level above sea. These are probably volcanic pipes through which the lava was forced and extruded at the surface.

The author compares the rocks of the bosses with those of the dykes and flows. Both are principally perfectly fresh dolerites, but the former are distinguished by the presence of intergrowths of micropegmatite as the last stage of consolidation, as in the "Konga diabases." There is also among them a felsite-breccia with micropegmatite developed in the cracks.

He considers that nearly all the igneous rocks of Cutch have been derived from a single magma, which in a solid condition must have contained large crystals of augite, olivine, and ilmenite in a groundmass of lime-felspars, and have been throughout of a basic character. Such a magma originated in more than one centre. One was possibly not far from the Sindree basin, whence lines of weakness diverged. Along these, owing to the thickness of the strata, there was no extrusion at the surface, and laccolite-domes were formed. Where the rock reached higher levels, it spread out into sheets between the domes and aided in the production of synclinals. Another centre was west of Bhuj, where the rock reached the surface without materially disturbing the sedimentary rocks, and formed the so-called "stratified traps." There were also areas here, especially to the south, where escape was impossible and domes were formed.

The author observes that his conclusions, if correct, may be applied to explain the source of the Deccan trap without eruptive centres. It may have been forced out from innumerable orifices as from a sieve, none of these being so much larger than others as to make a definite centre.

II.—June 9, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "The Cretaceous Strata of County Antrim." By W. Fraser Hume, D.Sc., F.G.S.

The paper, which deals with the Irish Cretaceous strata, is divided into four parts.

(1) This contains a detailed account of the principal subdivisions, their local distribution and characteristic fossils. The area occupied by these rocks is separated into five divisions, each marked by special lithological and palæontological features. These are—(*a*) The Southern Division, extending from Moira to Lisburn. Here the highest zone of the Chalk, that of *Belemnitella mucronata*, rests directly on the Triassic strata, the junction-bed containing large pebbles, associated with the above-mentioned species. (*b*) The Central Division, mainly including the sections between Lisburn and Belfast. All the main lithological features are here displayed, namely: (i) Glauconitic Sands (a blue-green rock rich in glauconite); (ii) Glauconitic Marls; (iii) Yellow Sandstones (a light calcareous sandstone); (iv) Chloritic Sands and Sandstones of the *Exogyra columba* zone (yellow-green sands and sandstones); and (v) White Limestone. Under No. iii Tate and Barrois both included the zone rich in *Inoceramus*-fragments occurring in the next division, but this zone is different in colour and chemical composition, and is practically absent in the Central area, the White Limestone with conglomeratic or nodular chalk at the base resting unconformably on the lower beds. Palæontologically, all these lower beds are rich in large dimyarian bivalves, especially *Trigoniæ*, *Arca*, *Cucullæa*, etc.

(*c*) The Eastern Division, extending along the Eastern coast from the neighbourhood of Carrickfergus to north of Carnlough, including Island Magee. The Glauconitic Sands and Yellow Sandstones with chert are present, but generally thinner than the same beds in the Central area. In them dimyarian bivalves are very rare, Brachiopods of stunted forms, corals, and sea-urchins having been, on the contrary, only found in them in this eastern region. The *Exogyra columba* zone is barely represented, but the *Inoceramus Crispi*? zone (which Tate thought to be below that of *Exogyra columba*) attains a thickness of over 20 feet, and evidence is brought forward to show that it overlies the *Ex. columba* zone. There is a palæontological unconformity between the two zones, the *Inoceramus*-beds passing insensibly into the White Limestone without the intervention of a conglomeratic bed. (*d*) The Peninsular Division. In the northern portion of county Antrim, the highest zones of the White Chalk rest on Archæan, Carboniferous, and Triassic rocks (which must have formed a peninsula or insular area in the Cretaceous sea), the basal conglomeratic bed being well marked, and old Cretaceous beaches preserved. Finally (*e*) The Northern Division. This occupies a strip on the northern and north-eastern shores, and includes Rathlin Island. The lower beds are only feebly developed, while the three highest zones of the White Limestone (*Belemnitella vera* to *B. mucronata*) attain a great thickness, and are very pure chalk-beds. Taking the various divisions together, it is concluded that Divisions *b*, *c*, and *e* first underwent depression, area *b*, being nearest to the shoreline, Divisions *a* and *d*, being higher ground, and only becoming submerged at a late period in Upper Chalk times.

(2) Chemical and Micromineralogical examination of the lithological types.—The Glauconitic Sands are characterized by the abundance of glauconite (23 per cent. $CaCO_3$), showing evidence of having been formed in the interior of foraminiferal shells; the Glauconitic Marls by an abundance of spheres and rods of pyrites; the Yellow Sandstones by a series of heavy minerals, notably rutile, zircon, tourmaline, kyanite, and perfectly-formed crystals of garnet; the *Inoceramus*-zone contains delicate glauconitic meshworks of hexactinellid sponges and silicified portions of *Inoceramus* and Brachiopods, besides an abundant series of heavy minerals. In the Chloritic Chalk above the Glauconitic sponge-casts become very abundant, associated with delicate casts of Foraminifera; the White Limestone itself has scarcely any residue. The analyses show that the percentage of carbonate of lime increases steadily from base to summit, the Glauconitic Marls alone being an exception.

(3) This section deals with the stratigraphical conclusions. The Glauconitic Sands, regarded by Tate as equivalent to the lower portion of the Upper Greensand, and by Barrois as synchronous with the upper beds (*Pecten asper* zone) of the same formation, are regarded as having commenced to be deposited in the earlier portion of that period, and to have been still forming during the *Pecten asper* times in England. The Yellow Sandstones with chert are mainly equivalent to the Warminster Sandstones with chert in the south-west

of England. The above two beds therefore constitute the Upper Greensand in Ireland. The *Exogyra columba* and *Inoceramus Crispi*? zones were both considered by Tate as Cenomanian, and by Barrois as Turonian. In the present paper they are considered as absolutely distinct, the *Exogyra columba* zone being truly Cenomanian (as limited by Jukes-Browne and Hill); the *Inoceramus Crispi*? zone, on the contrary, being similar in its fauna to the Chalk Rock and lowest Senonian beds in England, and on theoretical and faunal grounds being in preference assigned to the latter.

The *Micraster*-zones of the Senonian have been directly recognized, but the higher ones of *Belemnitella vera* (*Marsupites*) and *B. quadrata* are well represented. The nodular beds at the base of the White Chalk are of varying age, but generally referable to the above two zones. The conclusion arrived at is that there was a gradual depression followed by a partial elevation, and subsequent depression of a far more pronounced character. The Central Division being nearer the shore, the deposits of detrital material here formed were thicker, but at the same time during the period of elevation the denudation was more considerable, so that the unconformity is very marked; in the Eastern Division, where the sea is considered to have been deeper, the detrital deposits were not so thick and denudation less pronounced; on depression commencing at the beginning of the Senonian period, limestones containing a Chalk Rock fauna were being laid down here, while denuding influences were still active in the Central area. Speaking generally, there was a deepening northward of the Cretaceous sea, but the high ground in the north of county Antrim and south of Lisburn was the cause of the very marked beach and conglomeratic features observed in the Peninsular and Southern districts.

(4) *General Questions.*—The author here touches on and discusses (i) the occurrence of certain organic remains in the glauconitic sands and yellow sandstones of the Eastern division, which suggest higher zonal conditions than those indicated by the species with which they are associated; (ii) the great development of the *Exogyra columba* beds south of Belfast and their feebleness north of that town, while the opposite holds in the case of the strata with *Inoceramus*-fragments and *Spondylus speciosus*; (iii) cases of unconformity and overlap in the series; (iv) the existence of definite beaches of Upper Chalk age; (v) evidence in favour of the influence of currents; (vi) the relation of the Spongiarian bands to the strata above and below; (vii) faunal repetitions; and (viii) the general distribution of the *Rhynchonellæ* and *Terebratulæ*.

2. "An account of the Portraine Inlier." By C. I. Gardiner, Esq., M.A., F.G.S., and S. H. Reynolds, Esq., M.A., F.G.S.

At the north-western corner of the inlier a coarse conglomerate, referred to the Old Red Sandstone, dips in a north-westerly direction, and from beneath it a series of green and purple andesites having a south-easterly dip appear. These andesites have undergone considerable change since their extrusion. They are succeeded by a conglomerate of varied character, of which the matrix is at first an ashy shale, including fragments of ash, andesite, shale, and limestone. Interbedded with the conglomerate are bands of limestone and shale, which have yielded fossils of Middle Bala facies. The authors give reasons for maintaining that this conglomeratic series is not due to earth-movement, but is a sedimentary accumulation, though the case is otherwise with a conglomerate developed along a thrust-plane which separates the volcanic series from an overlying limestone. This conglomerate is compared with one recently described in the Isle of Man, though the alteration which marks the latter is practically absent from the former.

Igneous rocks like those found to the north-west of the outlier are also seen at the southern end.

The general succession of the greatly disturbed Portraine Limestone Series from above downwards is: (3) thin-bedded limestone, with shaly partings; (2) beds of compact crystalline limestone, with many fossils; (1) thin-bedded limestones, with shaly partings: the upper beds being in places crowded with corals. This limestone is comparable with the Chair of Kildare Limestone, and also with the *Staurocephalus*, Keisley, and Sholesbrook Limestones of Great Britain. Succeeding the Limestone Series, and separated from it by a thrust-conglomerate, is a Grit Series, which has yielded no fossils, but which resembles the Balbriggan Grits containing black shales with Birkhill graptolites.

Mr. F. R. C. Reed, M.A., F.G.S., in an Appendix, gives a list of the fossils found by the authors, and offers some remarks upon the age of the deposits.

3. "Some Igneous Rocks in North Pembrokeshire." By J. Parkinson, Esq., F.G.S.

The acid rocks described in this communication are situated at the east end of the Prescelly Hills. Organisms have occasionally been found; and some discovered half a mile west of Crymmych, at the west end of the area, point to an Upper Arenig or Lower Llandeilo age for the deposits.

The masses of acid rock which occur at Foel Trigarn and Carn Alw show all the characteristics of a true lava-flow. The rock often shows beautifully developed flow-structure. Some of the rocks are very markedly spherulitic and axiolitic. The axiolitic rocks display an interesting structure which the author believes to be best explained by concluding that during the formation of the axiolitic growths a slight movement occurred in the unconsolidated magma. He gives a full account of the variations which mark the spherulitic and axiolitic structures, and also describes nodular bodies produced by flow-brecciation accompanied by very feeble radial growth, and showing irregular but more or less central quartzose areas.

After describing a brecciated rock, which on the whole is best accounted for by a process of flow-brecciation, due to a second lava breaking up the first while it was still in a plastic condition, the author describes true pyroclastic rocks, and concludes with a description of the conspicuous intrusive diabases, which, in part at all events, seem to be of the nature of a laccolitic intrusion.

CORRESPONDENCE.

RECENT VOLCANIC ASH BEDS.

Sir,—On May 29th I examined some sections at Neilston, in Renfrewshire, pointed out to me by Mr. John Mackie, M.E., of that place. They are just to the east of the extensive Thread Works, and are exposed by the levelling of the ground for an extension of the same factory. The principal sections at present exposed are three in number:—

(*a*) Next the present works (north-west side of cutting) there is fine sand pretty regularly bedded, with a little cross-bedding, and blocks in it up to 5 feet in diameter.

(*b*) At the south-west side of cutting there is coarse gravel with a little sand—at some places with clay—with blocks up to 7 feet in diameter. The blocks are mostly traps of the neighbourhood; some of them are striated. I saw two fine-grained greywackes; and Mr. Mackie has had carted up to his garden a block of grey granite with large felspar crystals.

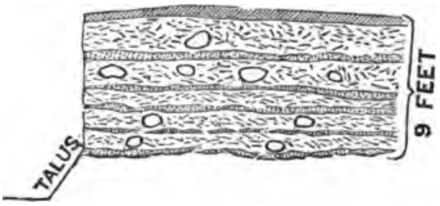
(*c*) The most interesting section of all is towards the south-east of the cutting. The material between it and the other two sections had been cut away before I saw it, so that its relative position to them could not be made out.

It is composed of Volcanic Ash Beds interlaminated with irregular beds and bands of loose sand. Part of the Ash occurs as consolidated masses apparently concreted in position (they do not appear to be bombs).

The ash is so pure, that it is difficult to understand how it could have come there unless it had been thrown out of a volcano; and the loose sand interbedded with it gives the deposit an exceedingly recent appearance.

There is nothing in the section to indicate its relationship to any known deposit, and it would be mere conjecture to suggest to what age the Ash Beds may belong; an exposure of perhaps 150 feet in length can be examined, and at one part I counted five beds of sand in a vertical face of ash of 9 feet in depth.

Surface of Ground.



Loose sand interbedded with Volcanic Ash, Neilston, Renfrewshire.

John Smith.

Monkredding, Kilwinning, *May* 31, 1897.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. VIII.—AUGUST, 1897.

ORIGINAL ARTICLES.

I.—*Hapalocrinus Victoriæ*, n.s., Silurian, Melbourne, and its relation to the Platycrinidæ.

By F. A. Bather, M.A., F.G.S.

(PLATE XV.)

Description of the Type-specimen.

THE specimen herein described was sent me by Mr. T. S. Hall, M.A., of Melbourne University. It was found by Mr. F. P. Spry in a rock of supposed Silurian age, at the Yarra Improvement Works, near Prince's Bridge, Melbourne, in November, 1896. The matrix is a fine-grained micaceous sandstone, of a dark purple-grey, weathering yellowish. It often contains crinoid columnals, such as were long ago noticed by the Geological Survey of Victoria,[1] and were figured by W. Blandowski as "*Cyatocrinites* (probably) *pinnatus*"[2]; but neither from here, nor from any other Silurian rock of Australia, has a crinoid crown hitherto been recorded. The remains of the crinoid are in the form of an impression, coloured red by iron-oxide; all calcareous matter has been dissolved away. The counterpart of the impression has not been preserved. The specimen was studied by means of wax squeezes; the drawing (Plate XV)[3] represents such a squeeze; and the description follows the drawing.

The crinoid, regarded thus, is seen to lie with its ten arm-branches fairly regularly extended, having their ventral grooves downwards; the dorsal cup, which would naturally lie base upwards, is bent over so that its apex or base points towards the bottom of the drawing; no trace of stem remains.

The Dorsal Cup appears to consist of two circlets of plates, basals and radials.

The number and shape of the Basals cannot be seen clearly. Apparently these plates were small; the non-appearance of sutures suggests that they were not more than three in number.

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[1] A. R. C. Selwyn, "On the Geology of the Gold-fields, etc.": Quart. Journ. Geol. Soc., xiv, 533–8, 1858.

[2] "A Description of Fossil Animalculæ in Primitive Rocks from the Upper Yarra District": Trans. Phil. Soc. Victoria, i, 221-3, with plate, 1855. See figs. 309-14 and 361.

[3] *Hapalocrinus Victoriæ*, from a wax squeeze of the unique type-specimen, × 5 diameters. Owing to the imperfection of the specimen, every single line in this cannot be vouched for; but the general relations and the details in the immediate neighbourhood of the calyx are believed to be correctly represented.

The Radials, five in number, appear to have been much wider above than below; but the intra-radial sutures are not clear, and the appearance is no doubt due in part to the flattening of the cup. The facet for the arms occupies about one-third the width of the radial.

The TEGMEN can be dimly seen, stretching up between the arms, to a height about equal to that of the dorsal cup. It appears to join on to the primibrachs, but is enough depressed between the arms and distinct from the radials to be considered no part of the dorsal cup. In other words, while the crinoid is not Inadunate, neither is one of the highly developed Camerata. The number and arrangement of the tegminal plates is not to be distinguished.

The height of the calyx from its base to the top of the tegmen is about 3 mm.

The 5 ARMS each branch once, on IBr_3; the total length is 15 mm.

The 3 Primibrachs (IBr) are joined to the tegmen as far up as the lower part of IAx. Their width is about ·5 mm.; the length about half as much again.

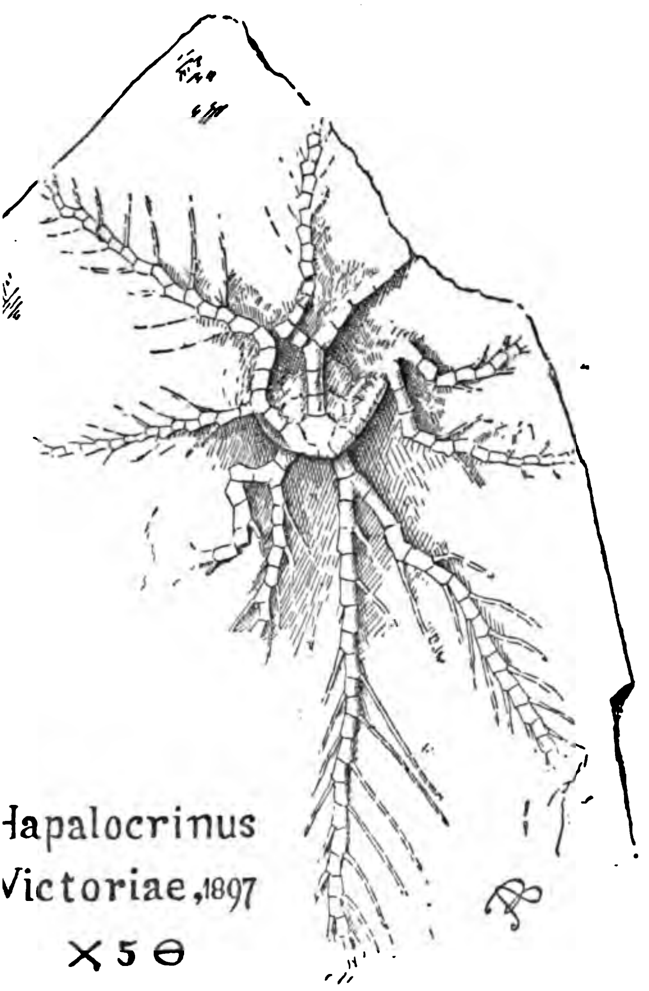
The Secundibrachs (IIBr), which begin by being slightly less wide than the IBr, are about half as long again as wide. The width gradually decreases to the end of the arm.

Pinnules, alternating from side to side of the arm-branch, are borne by each IIBr, except the first, and perhaps the second. The facets for the pinnules are well marked, so that the long axes of the IIBr form a slightly zigzag line. The greatest length of pinnule observed is 4·75 mm., its width being ·125 mm. The pinnulars appear to have been long.

THE SILURIAN AND DEVONIAN PLATYCRINIDÆ.[*]

The monocyclic base, the simple and apparently symmetrical cup, the slender pinnulate arms, and the lofty tegmen prevent us from seeking the relatives of this crinoid among the Inadunata (whether Larviformia or Fistulata, Monocyclica or Dicyclica), the Flexibilia of Von Zittel (=Articulata, *pars*, Wachsmuth and Springer), or those Camerata in which the lower brachials and interbrachials form an important part of the dorsal cup (e.g. Reteocrinidæ, Actinocrinidæ). Limiting our survey to the older Palæozoic crinoids, we see left only a group of genera, which Von Zittel, in his "Grundzüge der Palæontologie," 1895, refers to the Larviformia and the Platycrinidæ, which Wachsmuth and Springer include in the Platycrinidæ, but which Jaekel, in his fine "Beiträge zur Kenntniss der Palæozoischen Crinoiden Deutschlands" (*Pal. Abhandl.*, viii, Heft 1; Jena, 1895), distributes among both his Order Cladocrinoidea and his Costata, a Suborder of his Pentacrinoidea.

Among the Silurian and Devonian representatives of this group are *Cordylocrinus*, *Culicocrinus*, *Coccocrinus*, *Hapalocrinus*, *Agriocrinus*, and *Thallocrinus*. These all agree in having a dorsal cup composed of a pentagonal monocyclic base of three basals, one small and two large, and a circlet of five radials unbroken by any anal plate. The two primibrachs, though joined to the calyx wall by interradially situated plates, stand out clearly from those plates, and likewise



A new Silurian Crinoid from Melbourne, Victoria.

emain distinct from the radials. From the primaxil onward the rms are free, and occasionally one or both of the arm-branches ork again; pinnules are borne on each or on every other brachial; he IIBr (and IIIBr when present) may be uniserial, in zigzag, iserial, or fused in pairs. The interradially situated plates above nentioned belong rather to the tegmen than to the dorsal cup, he proximal ones only being to a certain extent interbrachial. The nus penetrates one of the interradial areas without materially ffecting the symmetry of the calyx, and there is no anal tube.

This set of characters might be thought to define a fairly omogeneous group; and yet the relationships of individual genera o other genera of very different families, and even orders, have to ome writers appeared so close that there has been great diversity n previous attempts at classification. For instance, the type of *Coccocrinus* was originally described by C. F. Roemer ("Rhein. Uebergangsgeb.," p. 63, pl. iii, fig. 3, 1844) as *Platycrinus rosaceus*; but Joh. Müller, in erecting the genus, considered that it was most closely allied to *Haplocrinus*.[1] D'Orbigny had already placed it, along with the *Cyathocrinus inæquidactylus* of McCoy, in a genus *Amblacrinus* next to *Cyathocrinus* ("Prodrome de Pal.," i, pp. 104, 156, and "Cours E'lémentaire," i, p. 145: Paris, 1849). C. F. Roemer doubtfully accepted *Coccocrinus*, as well as the position assigned to it by Müller, in "Lethæa Geognostica," 2nd edition, i, p. 229, 1855. F. J. Pictet also placed *Coccocrinus* in a family Haplocrinidæ ("Traité de Paléont.," ed. 2, iv, p. 310, 1857), and yet, referring to *Amblacrinus* (op. cit., p. 332), he says of the same species: "je n'ai pas pu comprendre en quoi ce diffère des vrais Platycrinus." Zittel's "Handbuch der Paläontologie" associates *Coccocrinus* with *Haplocrinus*; while P. H. Carpenter[2] and Wachsmuth & Springer have assigned it to the Platycrinidæ. Despite the arguments of these writers, Von Zittel, in his "Grundzüge," erects a family of Larviformia—the Coccocrinidæ—including *Coccocrinus* and *Allegacrinus*. Finally, Dr. Otto Jaekel, while recognizing the affinities of *Coccocrinus* to the Inadunata, especially *Hoplocrinus* (including *Bærocrinus*), places the genus in his family Hapalocrinidæ, far removed from the Platycrinidæ, in his suborder Costata. On the other hand, Wachsmuth and Springer would doubtless have included the Hapalocrinidæ in the Platycrinidæ, perhaps even in the single genus *Cordylocrinus*, to which they do actually refer the well-known Dudley species, *Platycrinus retiarius*, Phillips, which Jaekel puts in his new genus *Thallocrinus*.

While not denying a possible connection between the Hapalocrinidæ and the Plicatocrinidæ, and while recognizing the close affinity of the proposed suborder to the Inadunata Monocyclica, I must confess that I cannot find in Dr. Jaekel's detailed and suggestive description any grounds for severing *Coccocrinus*, *Thallocrinus*, and the rest from *Cordylocrinus* and *Culicocrinus*. The difficulties of the systematists seem to have arisen from the fact that the whole assemblage is intermediate between the older representatives of Inadunata Monocyclica and the Carboniferous forms of Platycrinidæ. In the "Crinoidea of Gotland," i, p. 19,[1] I suggested that the Camerata might have been derived from the Inadunata, and that such genera as *Platycrinus* might "represent stages in the evolution not far removed from the true Inadunate type." Dr. Jaekel's criticism of this sentence is based partly on the erroneous inference that I regard *Platycrinus* "als den Ausgangspunkt der Entwickelung der Cladocrinoideen (*Camerata*)" (op. cit., p. 38), and partly on his own supposition that *Platycrinus* is descended from *Marsupiocrinus* because the latter is older in geological time. It was only by getting *Coccocrinus* and "*Platycrinus*" *retiarius* conveniently out of the way, and by overlooking *Cordylocrinus*, that Dr. Jaekel could have written thus. All that is known of the ontogeny and phylogeny of crinoids favours the view that these and the allied genera mentioned above were derived from genera with a cup composed solely of 5 BB and 5 RR, with dichotomous arms clearly distinct from the cup, with the greater part of the tegmen covered by five large plates, between which the ambulacra passed to the mouth, and with very slight disturbance of symmetry due to the anus. On the other hand, *Cordylocrinus*, *Coccocrinus*, and their allies gave rise, in their turn, to the more highly specialized forms, first *Marsupiocrinus*, and at a later date *Platycrinus* and *Eucladocrinus*.

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[1] Müller in Zeiler und Wirtgen, "Bemerk. ueber d. Petrefacten, etc.": Verh. naturhist. Ver. preuss. Rheinl., Jahrg. xii, p. 21. (Bonn, 1855.)

[2] In Nicholson and Lydekker, "Manual of Palæontology," i, 428, 1889.

REVISION OF *CORDYLOCRINUS* AND THE "HAPALOCRINIDÆ."

Before considering to which genus the Melbourne specimen is most nearly related, some revision is required.

Wachsmuth and Springer ("Monogr. N. Amer. Camerata," ii, p. 735, 1897) have placed "*Platycrinus*" *retiarius* in *Cordylocrinus*. But according to Angelin's "Iconogr. Crin. Suec.," pl. xxiii, fig. 6, *C. comtus*, the type-species, bears two pinnules on each IIBr. The brachials are therefore compound, derived by fusion from biserial or zigzag pairs. The same appears from Hall's figures ("Palæont. N.Y.," iii, pl. iv) to be the case with the American species which Wachsmuth and Springer refer to this genus. Certainly the same arm-structure obtains in the undescribed Dudley species with two arms to the ray, mentioned by those authors on p. 736. In "*Platycrinus*" *retiarius*, however, the IIBr are uniserial, approaching the zigzag arrangement, and each bears one pinnule. This is surely enough for generic distinction.

Dr. Jaekel calls the last-mentioned species *Thallocrinus retiarius*, so that we must now consider the claims of the genus *Thallocrinus* to recognition. Jaekel's family Hapalocrinidæ is thus defined (op. cit., p. 94):—"Dorsal cup consists of a circlet of large spade-shaped radials, and a tripartite (2 + 1) occasionally fused basal circlet; tegmen essentially composed of five large orals, but sometimes there are distinct suborals [interbrachials]. The five arms fork

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[1] K. Svenska Vetenskaps-Akad. Handl., Bd. xxv, No. 2. (Stockholm, 1893.)

the second brachial into two main branches, which occa-
y branch again. Each of these branches bears alternately
›d ramuli ["pinnules" of most authors], with very elongate
ı. The columnals at some distance from the cup are very long,
thickened ring in the middle, and often provided with cirri."
family includes the genera *Hapalocrinus*, *Agriocrinus*, *Thallo-*
and *Coccocrinus*, of which the first three are new and based
species from the Hunsrückschiefer of Bundenbach. The
›ecimens, unfortunately, like most of the Bundenbach speci-
at which Dr. Jaekel has worked with such zeal and
;ence, are very difficult of interpretation. The characters
d by the author of the genera as diagnostic may, so far
are known, be set out in the following table:—

	Hapalocrinus	*Agriocrinus*	*Thallocrinus*	*Coccocrinus.*
	3	?	3	3
ı	r. anterior	?	l. anterior (?)	l. ant. apud W. and Sp. Position varies apud Jaekel
	with axial folds	axial folds in some spp.	smooth	smooth
	closely joined to suborals	?	?	5 large
s"	4 in post. IR	?	fused exc. in post IR	single
	in oral	?	?	between oral and suboral
	fork once	fork once; sometimes twice	fork once in type-sp. [twice in *T. retiarius* sometimes]	fork once; beyond which is unknown
es	regularly alternate; one on each IIBr, or on every other one [text and plate not consistent]	regularly alternate; one on each IIBr, or on every other one	regularly alternate; one on each IIBr	?
als	long; with swollen ring in middle	short; with median thickening	short; with median thickening	short; ?
	radical only	radical, and occasionally on stem	no cirri in type-sp. (?) [all along stem in *T. retiarius*]	?

o things are made clear by this table. First, that *Thallocrinus*
ius does not agree with the type-species or with the original
osis of the genus in two supposed diagnostic characters. Second,
›he differences between these genera are very slight and based

on very variable characters. The case is even less hopeful when we consider other species than the type-species, such as *Agriocrinus inermis*, which the author himself admits to be intermediate between *Hapalocrinus* and *Agriocrinus*, but which in some respects is even more like *Thallocrinus*. *Coccocrinus* seems to be distinct, in its large orals, single suborals or interradials, and the position of its anus. We know, it is true, very little about these features in the other forms, but what we do know suggests a somewhat different structure, and it would be well to keep them apart from *Coccocrinus*. But to split them up into three genera, is surely inadmissible on the evidence at present available.

I propose, therefore, to merge all these in one genus; for this we are bound to take the name of the type-genus of Jaekel's suggested family, viz. *Hapalocrinus*; and the type-species will be *H. elegans*, of which Jaekel has given so complete a description. The family Hapalocrinidæ lapses, since the genus falls into the Platycrinidæ as defined by Wachsmuth and Springer ("Monogr. N. Amer. Camerata," ii, 642, 1897). Their diagnosis of that family runs thus:—

"Monocyclic. Brachials and interbrachials only slightly represented in the dorsal cup; the lower brachials taking more or less the form of free arm-plates; the lower interradials in part interambulacral in position, rarely entirely interbrachial. Radials in contact all around, there being no special anal plate. Basals forming a pentagon." To this must be added: Two pairs of the primitive 5 BB fused, the small unfused B being usually the left, sometimes the right, anterolateral.

The genus *Hapalocrinus*[1] may be diagnosed thus:—Unfused B left or right anterolateral. Orals not large or distinct. Interbrachials (suborals of Jaekel) more than one (at least in post. IR). Ambulacrals (covering plates) visible between orals and interbrachials. IBr 2 (? sometimes 3). Arms fork once, sometimes twice, varying in this respect in the same species (or even individual). IIBr (and IIIBr when present) uniserial, or slightly in zigzag, bearing alternately disposed pinnules, either on each or on every other brachial, with pinnulars longer than wide. Stem circular in section, with small axial canal, relatively long and slender; the columnals, especially the nodals, with a median thickening. Cirri are present at the root, and often on the nodals of the rest of the stem.

To these characters it may be added that some species (e.g., *H. elegans*, *H. Frechi*) show axial folds passing from the radial facets to the basals; and that some species (e.g., *H. elegans*, *H. Frechi*, *H. retiarius*) have an ornament of slight longitudinal grooves on the brachials.

Coccocrinus differs from *Hapalocrinus* in its large, symmetrical orals, which almost cover the ambulacra, its single interbrachials, and (?) the position of the anus. *Culicocrinus*, which closely resembles

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[1] ἁπαλός, 'tender,' like roast sucking-pig or the cheeks of a maid, also delicate in health. The extreme appropriateness of the name must excuse its close resemblance to *Haplocrinus* of the same geological age, as well as to *Hoplocrinus*, with which it is associated by its author.

Coccocrinus in the calyx-structure, further differs from *Hapalocrinus* in its heavy, biserial arms. *Cordylocrinus* is very closely allied to *Hapalocrinus*, but differs in the compound nature of the IIBr, each of which bears two pinnules. *Marsupiocrinus* has but one IBr, biserial arms, and a large five-lobed axial canal in the stem. *Platycrinus* and *Eucladocrinus* have but one IBr, biserial arms, and stem of elliptic section.

In its arm-structure, then, *Hapalocrinus* is more primitive than any of the Platycrinidæ, except perhaps *Coccocrinus*, of which the arms are unknown; in its tegminal development it seems to be about on the same level as *Coccocrinus*, though perhaps a little further removed from the Larviform type. This stage of evolution consists with its geological range, which is from Middle Silurian to Lower Devonian.

Reference of the Melbourne Crinoid to Hapalocrinus.

In its arm-structure, and, obscure though it be, in the composition of the tegmen, the Melbourne crinoid appears more closely allied to *Hapalocrinus* than to any other genus with which I am acquainted. It has, however, three IBr, whereas no other Platycrinid has more than two. Therefore, if it be placed with *Hapalocrinus*, we must regard it as in this respect more primitive than the other species. It is also at least as primitive as any other *Hapalocrinus* in the structure of the IIBr and pinnules. It would be unwise to found a new genus for the reception of this unique and rather obscure specimen, so I refer it provisionally to *Hapalocrinus*.

As there can be no question that it represents a distinct species, it requires a trivial name. I received the specimen and studied it during the week of Her Majesty's Diamond Jubilee; this fact, and the fact that it is the first Silurian crinoid crown found in the colony of Victoria, inevitably suggest the name—

Hapalocrinus Victoriæ.

Diagnosis.—IBr 3; arms fork once; IIBr half as long again as wide, in zigzag, bearing alternately disposed delicate pinnules.

The type-specimen will be placed in the museum at Melbourne University by Mr. T. S. Hall, to whom, in conclusion, I express hearty thanks for giving me the opportunity of studying this highly interesting fossil.

II.—Notes on the Age and Structure of the Gneissose-Granite of the Himalayas with reference to Mr. Middlemiss's Memoir on the Geology of Hazara.

By Lieut.-General C. A. McMahon, V.P.G.S.

PART II.

Origin of the Foliation.

In the first part of this paper I confined myself to the consideration of the age of the Himalayan granite; in this I propose to discuss Mr. Middlemiss's views regarding the cause of its foliation.

Mr. Middlemiss appears to be so satisfied in his own mind that the foliation has been produced subsequent to the consolidation of the rock by pressure-metamorphism, that he considers it unnecessary to discuss the facts and arguments that I have from time to time brought forward to show that pressure *before* consolidation was the efficient cause of the foliation of the Himalayan rock. I shall, as far as possible, refrain from repeating in this paper what I have previously written on this subject, and shall content myself with referring the reader to my address, as President of the Geologists Association (Proc. Geol. Assoc., xiv, p. 287), for a condensed presentation of my case. On the present occasion I shall confine my remarks to a statement of supplemental facts and arguments.

Mr. Middlemiss's hypothesis, given in his own words, is as follows:—"Just as the mineral composition of the great crystalline axis of the Himalaya has been found to be the same right through from end to end of the chain, so is it also found to be the case that the dynamic metamorphism of those rocks is also a constant factor throughout the range.

"I do not think there can be two opinions as to the origin of this state of things. It can only imply a steadily acting lateral pressure of the earth's crust tending to bank it up against the central crystalline core by a movement and a resistance in two opposite directions. To the south we have the newer zones of disturbance showing no dynamic metamorphism; but to the north the accumulated pressures consequent on the upheaval of several zones one after the other, with the gradually diminishing in size of the larger earth-folds as the centre of the solid crystalline core is approached, have all tended to bring about that intense cleaving, shearing, and deformation of the minuter particles of the rock which I embrace generally under the head of dynamic metamorphism" (p. 279).

The author tells us (p. 61) that the gneissose-granite "is present in the form of intrusive bands among the schistose rocks"; that these "bands are generally parallel to the foliation of the rocks among which they lie"; and that the foliation of the granite is "perfectly parallel to that of the schists" (p. 66). Some of the granite is foliated, but some is not (p. 64). The non-foliated variety represents the "original condition in which the rock first solidified after intrusion among the sedimentary rocks of the region" (p. 64); and the foliated variety has been derived from it "by the mechanical action of pressure metamorphism" (p. 64); "acting on the rock since the time it became a solid stationary mass" (p. 65).

The evidence on which the author appears to rely for proof of his position may be summarized as follows:—

(1) The crushed condition of the Himalayan rocks generally (p. 279).

(2) The parallel foliation and fissility of the rocks (p. 279).

(3) The fact that the foliation of the gneissose-granite is usually parallel to that of the schists, although there are exceptions to this rule (p. 66).

(4) That the gneissose-granite exhibits augen structure (p. 65).

(5) That the minerals have been rolled and dragged out (p. 65), and exhibit "flaser" structure (p. 72).

(6) That the pebbles in the Infra-Trias conglomerate have been flattened and deformed (p. 55).

(7) That coarse grains of quartz in the Infra-Trias sandstone have been powdered and drawn out to eyes (p. 56).

I may say at once that I fully admit, and for the matter of that always have admitted, the truth of the facts alleged in the above seven points. What I have always denied, and still deny, is, that the foliation of the granite was produced by crushing and shearing *after* it became a solid mass. I have all along contended that a foliated structure was impressed on the granite *before* its final consolidation.

No one, I presume, doubts that the birth of the Himalayas was accompanied by great earth movements, and that during the elevation of these lofty mountains great compression, contortion, faulting, and shearing of the strata took place on a grand scale. I certainly have never denied it; and I have expressly admitted that the gneissose-granite itself bears evidence of having suffered many things from the dynamic forces of Nature. For instance, I stated in my Presidential Address already referred to, that "the granite was forced in thick sheets between beds of strata, and into the faults and fissures opened up in the course of the compression, uplifting, and contortion of the rocks which set in within the Himalayan area at the close of the Eocene period" (loc. cit., p. 288). I pointed out that in one region of special strain "the gneissose-granite passes at its edges into a rock that might, without microscopical examination, be taken for a mica-schist" (loc. cit., p. 288). In another paper (GEOLOGICAL MAGAZINE, 1887, p. 214) I said that the outer band of gneissose-granite at Dalhousie "not unfrequently looks, viewed macroscopically, as if it had been flattened under a steam-roller"; and on the same page I detailed the evidence of strain, fracture, and traction, supplied by the microscope.

The point at issue, therefore, is not whether the Himalayan rocks generally, or the granite in particular, give evidence of having suffered compression, contortion, or fracture, but whether the foliation of the granite was produced prior to, or posterior to, the consolidation of the rock. The production of evidence to prove points not at issue is illogical. When no one denies that the rocks of the Himalayas have suffered contortion and crushing, what is gained by proving what is already admitted? Moreover, as the question raised concerns an igneous intrusive rock, evidence to show the crushing of sedimentary rocks is really irrelevant, unless it can also be shown that the crushing relied on took place *after* the entrance of the intruder.

The first and main point at issue in the case of the granite of the Himalayas, as before said, is whether the foliation was superinduced *before* or *after* the complete cooling and consolidation of the rock. Evidence to be of logical value must be directed to that issue.

From first to last I have contended that the foliation of the Himalayan granite was produced before the consolidation of the rock, and in my Presidential Address before referred to I tried to explain briefly that lateral pressure applied to an intruded igneous rock in which crystallization had commenced prior to its being moved into place, would, if the pressure were kept up during the subsequent stages of its cooling, whilst it was "gradually progressing towards rigidity," inevitably result in the production of foliation, and would account for the "undulose extinction, fractured minerals, and crumpled micas, and such like evidence of strain and mechanical action," to be found in the Himalayan gneissose-granite (Pres. Address, loc. cit., pp. 288–9). Given tangential pressure and strain exerted on an intruded granite during its gradual cooling, these results must follow.

The above explanation, at all events, offers a definite theory to explain the foliation and other phenomena to be observed in the Himalayan granite, and it is no answer to this theory to point to evidence of strain and mechanical action in the rock; for the existence of strain and mechanical action during the critical period in the history of the granite, is an essential part of the theory itself.

I have looked in vain through Mr. Middlemiss's Memoir for evidence, other than the above, to rebut my theory. My second Presidential Address, dealing with the structural characters of the granite, probably did not reach the author until after his Memoir was set up in type, but my address was, in the main, a condensed statement of a theory long held by me, and to be found in my previous papers. The one published in this Magazine in May, 1887, alluded to above, for instance, contains an abstract statement of the theory in question.

It may be as well to remark here that so far as the *foliation* of the Himalayan granite is concerned, the foliation set up was a change of structure only, and did not involve any metasomatic change in the chemical composition of the minerals. The foliation was, in its main features, a parallelism in the orientation of the minerals which already existed in the still plastic magma, and was superinduced by pressure applied before the final consolidation of the rock. The mineral principally concerned in producing the foliation was mica, an original mineral abundantly present in the granite before foliation set in.

Given an abundance of mica in a still plastic granite, I do not see how great pressure could be applied without causing the platy leaves of mica to arrange themselves with their flat basal faces at right angles to the direction of the pressure. We have here, then, a *vera causa* to account for the foliation of an igneous rock. Given a sufficient amount of mica, or other mineral of similar habit, and sufficient pressure applied between the formation of the mica and the consolidation of the rock, and we have a sufficient explanation of the foliation it may exhibit.

It may be as well to point out that the tendency of platy minerals to arrange themselves under pressure with their flat faces at right angles to the direction of the pressure, was probably aided by other contributory causes. Even after the granite was moved into place, and the crystallization of some of its minerals, begun in plutonic regions and continued after its intrusion into the sedimentary rocks, had progressed considerably, the still uncrystallized residuum, or mother liquor, must have been, to some limited extent, capable of flow or motion. Tangential pressure caused by earth movements, continuously acting on the granite, would probably force some of it into new fissures and newly-created planes of weakness, along the margins of the intrusive mass; and this marginal extension of the intruded granite, combined with a continuance of the tangential pressure, would create a slight flow in the unconsolidated mother liquor, sufficient to allow the mica and other platy minerals to yield to the pressure and orient themselves with their flat faces at right angles to it.

Further, it seems probable that the pressure exercised on the granite by the molten mass below it fluctuated from time to time. Deep-seated movements, such as laccolitic intrusions in neighbouring areas, or the extrusion of acid lavas at the surface, would, for a time, relieve this pressure and cause a small movement in or back flow of the mother liquor. In other words, fluctuations in the resistance offered by the molten mass under the granite would allow the partially consolidated granite to be compressed by the tangential pressure continuously exercised upon it.

A very small amount of interstitial movement would suffice to cause the flat leaves of mica to be arranged at right angles to the pressure, while a back flow to any extent, by depriving the crystallized minerals of the elastic support of the mother liquor, would lead to their crushing and deformation.

Those who have watched the operations conducted in a sugar refinery will readily understand that the mother liquor may be drained out of a mass of crystals without the crystals being carried away with it. I do not wish to suggest that the mother liquor was ever pumped out of the granite to any great extent: I only desire to make it clear that small interstitial movements might result from the causes above explained; and that even small movements would suffice to give the tangential pressure that was compressing the partially consolidated granite a free hand, so to speak, and permit it to impress a foliated structure upon the granite.

Interstitial motion created in the two ways suggested above—namely, by the marginal extension of the granite, and by a temporary diminution of the resistance offered by the molten mass below it—might be very local in its action, and hence some parts of a granite might become foliated while other parts remained unfoliated.

One more point remains to be mentioned. The earth movements that produce faults often persist for some time, and though a rupture in the folded strata gives temporary relief to the strain, the stress is sooner or later repeated, with the result that either the throw of the fault gradually increases, or the walls of the fault are moved up and down at intervals. Movements of the walls of a fault into which an igneous rock had been intruded would, as the solidification of the intruder approached completion, inevitably produce marginal foliation and pronounced crush-structures.

In the above remarks my chief object has been to bring before the reader, as clearly as I could, what I believe to be the main factor in the production of the foliation observable in the Himalayan granite. Other causes contributed to produce the effects observed. Traction when the rock was being moved into place,[1] and the corrosive action of the acid residuum on the phenocrysts, might be named; but it is needless to dilate on them here, as I have already written much in other papers on these themes. I am glad to see that Mr. Middlemiss recognizes the validity of the last-mentioned factor, for he remarks (p. 63) with reference to the porphyritic crystals: "The larger ones have often only a very vague outline in the rock, as if their boundaries had become indistinct from the reaction of the still molten magma upon them whilst the rock was in a half-consolidated state."

It is a great relief to be able to turn at this point in the discussion to an interesting and important piece of work in the Scotch Highlands by the officers of H.M.'s Geological Survey. I allude to the explanation of Sheet 5, Memoirs of the Geological Survey, Scotland, by Messrs. Horne, Peach, and Teall, 1896. In describing the granite of the south-east portion of the county of Kirkcudbright, Mr. Horne tells us at p. 23 that "the granite occurs mainly in the massive form throughout this extensive area, but there are certain limited tracts where it has a marked foliated character. The latter variety is a marginal phenomenon. It does not, however, extend continuously round the border of the igneous mass, being restricted to well-defined areas. . . . . As the observer passes inwards towards the centre, he finds the foliated variety of the border tract gradually to merge into the massive granite."

The granite contains basic inclusions and acid veins, which are also foliated, the foliation of the granite, basal inclusions, and acid veins having a common direction. "The evidence obtained in the field," Mr. Horne writes (p. 24), "clearly points to the conclusion that the foliation must have been superinduced on the massive granite with the basic inclusions, after the formation of the acid veins."

I infer, from what follows, that the acid veins must have been formed after the granite was moved into place, but before it cooled down. The foliation of the basic inclusions was evidently due to the cause that produced the foliation of the granite itself; and as the latter is attributable, as will be seen later, to pressure before cooling, I infer that the basic inclusions were made plastic by the contact action of the granite before the pressure was applied.

"After the development of the foliation," Mr. Horne continues (p. 25), "the foliated granite was injected by a well-marked series of dykes. . . . . These dykes run in a north-westerly direction, and have fine-grained or chilled edges. No single instance has been observed among them of any trace of foliation."

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[1] Sir A. Geikie mentions interesting cases of "extreme mechanical deformation by the movement of a still molten rock" in his paper on the Tertiary Basalt Plateaux of N.W. Europe (Q.J.G.S., vol. lii, p. 333).

In order to realize the full significance of the presence of unoliated dykes in the foliated granite, it is necessary to bear in mind hat the dykes appear to have been derived from the same source of supply as the granite itself. Mr. Teall tells us at p. 45:—"It follows from the above description, that there is very little difference in composition between the dykes of this type and the granitic rocks of the Criffel and Dalbeattie mass. . . . . It is probable, therefore, that the structural differences between the porphyrites and the hornblende granites or quartz diorites are due to differences in the conditions under which the magmas consolidated. If we suppose that an intrusion of the granitic magma took place in dyke form after the greater part of the hornblende, biotite, and plagioclase had separated out, we shall have a satisfactory explanation of the difference in structure between the porphyrites and the granitic rock. In applying this theory, however, it must be remembered that dykes of the type now under consideration occur not only in the sedimentary rocks, but also in the granitic masses. Moreover, dykes are found in the foliated area unaffected by the foliation. Such dykes cannot be regarded as in any way representing apophyses of the granite. They belong to a later phase of igneous activity. The source of supply was probably the same as that from which the main igneous mass was derived; but if so, it must have been tapped at a time when crystal building had proceeded to a considerable extent."

It would appear, therefore, that although the foliation of the granite was affected after the formation of the acid veins, it was completed before the porphyrite dykes were intruded into the granite; and as the source of supply of the dykes and of the granite was probably the same, no great lapse, measured by geological time, is likely to have intervened between the foliation of the granite and the intrusion of the unfoliated porphyrite.

Mr. Teall, at p. 43, remarks:—"The interstitial movement which has resulted in the production of foliation, and which is proved by the field evidence to have been produced by earth-stresses operating after the rock had reached its present position, and after the formation of the acid veins, has not affected all the constituents alike. The quartz and alkali-felspar which, as we have already seen, were the last constituents to solidify, are those which have yielded most to the deforming stresses. They show signs of crushing, and frequently pass into thin micro-crystalline or even crypto-crystalline streaks, which wind round the comparatively uncrushed crystals of oligoclase. The distribution of the ferro-magnesian constituents has been modified by the movement. Instead of being irregularly distributed through the rock they tend to form flaser in association with the micro-crystalline aggregate of quartz and alkali-felspar. The oligoclase has been little, if at all, affected by the movement. These facts clearly prove that the minerals which yield most readily to the deforming forces are those which consolidate last. *It is probable that the pressure acted before the rock-mass had actually cooled.*" The italics are mine.

The above description of the petrographic characters of the Scotch rock might be applied word for word to the Himalayan granite. It is gratifying to be able to point to the independent evidence of an expert who shows that it is "highly probable" that the pressure which produced the foliation of a Scotch granite "acted before the rock-mass had actually cooled." It further appears from Mr. Teall's remarks that the granite was in a partially consolidated state when the pressure was applied. "The last constituents to solidify," he writes, "are those which have yielded most to the deforming stresses"; and the pressure applied to the uncooled and partially solidified rock crushed the quartz and felspar crystals to such an extent that they passed "into micro-crystalline and crypto-crystalline streaks." We get "flaser" structure, and, in the words of Mr. Horne (p. 25), "The quartz and alkali-felspar are the constituents which yielded most readily to dynamic agencies. The yielding of these constituents dragged out the biotite and hornblende." The correspondence of the Scotch and Himalayan rocks in the origin of their foliation, and in their crush and flaser structures, would seem to be complete; and the testimony of Messrs. Horne and Teall to the effect that these structures, in the case of the Scotch granite described in the above Memoir, were probably produced whilst it was still uncooled and incompletely solidified, is all the more important as these observers have been by no means unfavourable to the cause of dynamo-metamorphism.

If, then, we can get "flaser" structure, and the crushing and dragging out of minerals into streaks by pressure applied to an igneous rock prior to its complete cooling and solidification, it seems to me simply nonsense to appeal to flaser structure, crushing, and the dragging out of minerals, as conclusive evidence that the rock exhibiting these structures has been deformed *after* its consolidation. Those who wish to establish that conclusion for any particular igneous rock must produce good and convincing evidence to prove that the dynamic movements took effect *after*, and not *before*, its consolidation.

The condition of mind of those who think that it is only necessary to produce evidence of crushing to close controversy on the point at issue, reminds me of those who, in days gone by, exclaimed with enthusiasm as they stood gazing at a gabbro: "We know for certain that this is a metamorphosed sedimentary rock, *because* it is foliated!" Lest any should think this statement exaggerated I will give extracts from a recently published memoir (60th Report, U.S. Geol. Surv. 1894–5), "On the Principles of North American Pre-Cambrian Geology," by Mr. C. R. Van Hise. "A few years ago," he writes, "it was assumed as a matter of course that distinct lamination in the gneissose granites, gneisses, and schists, and the fact that these rocks were believed to grade into the clastics, were taken as conclusive evidence of the original sedimentary origin of the whole" (p. 748); and the author refers by name to five authors who, among others, actually acted on the above-mentioned principle. Van Hise also points out (p. 768) cases in which "laminated gabbro" was, in deference to this principle, written down as a sedimentary rock![1] I trust we have now nearly heard the last of arguments which may fairly be paraphrased into such a remark as—"This is a striking case of dynamo-metamorphism. It is quite evident that the rock was deformed by tremendous earth movements *after* its solidification, *because* it shows flaser structure and crushing, and some of its minerals have been drawn out into strings."

Turning again to Mr. Middlemiss's Memoir, there are some facts in it which, to my mind, raise difficulties in the way of the acceptance of the theory advocated by the author, and suggest the existence of evidence against it. Mr. Middlemiss tells us at page 75 of basic dykes which generally "form narrow bands or dykes roughly parallel to the foliation of the intruded rock"; but "in certain places the dykes cut across both the schistose series and the gneissose-granite intrusions, and also send off small veins into them." With the exception of the Indus Valley dykes, nothing is said about the foliation of the basic dykes that cut across the foliation of the schists. Are they foliated or unfoliated, and if the former, is their foliation parallel or at an angle to that of the schists? In fig. 4 (p. 76) one of the Indus Valley dykes is represented, and parallel fine white lines are to be observed along one edge of the dyke which appear intended to represent foliation. If these lines are intentional, and not an accident in printing, it is to be observed that they are at a high angle to the foliation of the schists and only occur along one margin of the dyke.

The author tells us (p. 75) that the dykes which cut through the gneissose-granite of the Indus are foliated along their edges. No information is given as to the direction of this marginal foliation in relation to the foliation of the granite; but it seems clear that the conditions under which the foliation was impressed upon the two rocks must have been different. If the foliation were imparted to the granite after its solidification, and after the intrusion of the dolerite, it is difficult to understand why the dolerite was not foliated from side to side.

In the detailed account of the Indus Valley section given in the Memoir (p. 253) a mass of dolerite is shown in fig. 51, as an intrusion in the schists parallel to their bedding. The section suggests the idea that the dolerite was folded up with the strata, and that the latter form a somewhat crushed anticlinal. The two dolerite bands on the right of the illustration might even represent the dying out of the dolerite seen on the left of the woodcut. The schists and the granite seen in this section appear from the author's general remarks (see ante, p. 346) to be foliated in a direction parallel to the folds of the bedding; but the dolerite, which was apparently folded up with the schists and the granite, and must have participated in the stress, crush, and shearing, which accompanied the folding of the rocks, is absolutely without foliation. If the tangential pressure which crumpled up the strata produced foliation in the schists and granite, how did the dolerite escape uninjured? This is the more remarkable as dolerite takes on foliation very readily. The author has not given any explanation of the difficulty.

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[1] "This gabbro," he writes, "was formerly regarded as a later sedimentary series!" (Loc. cit., p. 768.)

Mr. Middlemiss appears to rely very much on shearing and molecular movement to account for the results which he attributes to dynamo-metamorphism. "If we believe," the author writes, "(as we have a right to do from considerations as to the deep-seated nature of granite) that very great thicknesses of the slate or schistose rocks once overspread that crystalline core, we can understand that lateral stresses, if sufficiently powerful and long-continued, acting on such a material would be unable to violently fold and plicate them on a large scale, but would spend themselves in minute deformation of the rocks in shearing and in other ways characteristic of dynamic metamorphism" (p. 280).

If shearing and molecular movement took place in Mr. Middlemiss's crystalline and metamorphic zone to the extent supposed by the author, great heat must have been generated, and strong chemical action must have resulted. It is curious, therefore, to notice that these much "mashed" rocks, to use a term employed by geologists over the Atlantic, do not appear to have yielded the author much in the way of dynamo-metamorphic minerals. One reads of mica and of "incipient garnets," "which occur as minute specks or raised blisters" (p. 55), but I cannot call to mind anything else. This poverty of chemical and mineralogical result after the expenditure of so much dynamic energy recalls an ancient proverb to the effect that "a great mountain was in labour and brought forth a small mouse."[1]

I see no reason to believe that the great masses of gneissose-granite now to be seen in the Himalayas were "mashed" by pressure after cooling and solidification. In following outcrops along the line of strike, as for instance along the Shankan outcrop in the Simla regions (Records G.S.I., x, p. 217), the granite passes repeatedly from massive to foliated, and from foliated to massive, in an apparently capricious manner. This feature I think quite incompatible with the supposition that the foliation is the result of shearing subsequent to the solidification of the rock, either in the direction of the strike or in the direction of the dip.

I would again invite attention to the heliogravure of an inclusion in the Dalhousie gneissose-granite published at p. 174, in vol. xvii, Records G.S.I. The plate represents a cross-section of a splinter of schist two feet long, shaped like a tent-peg. The outlines of the inclusion are perfectly sharp, and it is evident that the granite in the locality where the inclusion was found cannot have been sheared after the inclusion of the fragment. Had shearing taken place the inclusion would have been flattened and drawn out into ribbons.

To sum up, I think that though the facts brought before us in Mr. Middlemiss's Memoir are interesting, they shed no new light on the origin of the foliation of the granite of the Himalayas, and do not in the least traverse the theory I have offered to explain that phenomenon. The evidence supplied in the Memoir under review is on points which are not only not in dispute, but actually form an essential part of my theory. Nothing more need be said by me unless a serious attempt be made to meet or disprove that theory.

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[1] "*Parturiunt montes, nascetur ridiculus mus.*"—Horace.

III. — THE GEOLOGICALLY RECENT ORIGIN OF THE SURFACE CONTOUR OF SCANDINAVIA AND FINLAND, AND ITS LESSONS.

By Sir HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

SOME time ago I discussed in this Magazine the recent geology of Greenland; and I ventured to argue, and, I think, to prove, that the general rise of that great island from the sea, which is conceded by every inquirer, has been unbroken, and that during the so-called Glacial period, instead of being a lofty plateau as it now is, it was a comparatively low-lying land. I ventured further to argue, and also, I think, to prove, that with the rise from the sea of this great island there has been a corresponding fall in its temperature, which is a very natural and simple *a priori* meteorological conclusion, and to adduce a number of biological facts to show that during the so-called Glacial period Greenland, instead of having been mantled with an ice-sheet as it is now, had a comparatively mild climate; and that its scanty fauna and flora, instead of having been the result of sporadic migrations thither since the so-called Glacial age, is, in fact, the expiring and shrinking remnant of a once much more important life. The facts and arguments I adduced have nowhere been traversed or met, and it seems to me they are unanswerable.

I now propose a more hazardous work, namely, to apply the same arguments I used in regard to Greenland to Scandinavia and its borders, more hazardous because Scandinavia is the very sanctum of the Glacial geologist, and in attacking him there we attack him in his citadel. I may premise my remarks by saying that I have paid two visits to Sweden, one to the island of Gothland, and one to Finland.

That Northern and Central Scandinavia have recently risen from the sea, has been known since the beginning of the last century, and has been the subject-matter of many memoirs and many researches, in which Lyell, among others, distinguished himself. I do not know anyone that disputes or denies the conclusion. The fact is thus stated by that picturesque and careful writer, Réclus:—Elevated beaches, which can be traced by the eye like the steps of an amphitheatre, are arranged in stages at various heights on the slopes of the mountains. Heaps of modern shells are found at heights of 500 to 650 feet above the level of the sea; and the great branches of pink coral formed by the *Lophohelia prolifera*, which lives in the sea at a depth varying from 1,000 to 2,000 feet, are now raised up to the base of the cliff.[1] The pine-woods, too, which clothe the summits, are continually being upheaved towards the lower snow limit, and are gradually withering away in the cooler atmosphere; wide belts of forest are composed of nothing but dead trees, although some of them have stood for centuries.[1] ("The Earth," p. 623.) Although this movement of the Norwegian land is widely recognized, it does not seem to have occurred to the champions of the Glacial theory that it has been going on for a long time; and so far as every geological piece of evidence goes, it extends back to the so-called Glacial period. There is evidence that this rise has taken place to the extent of 600 feet in certain parts of Norway. If this be so, then it follows that Scandinavia is much higher at present than it was at the period in question; and if so, it as necessarily follows that, *cæteris paribus*, its climate is now more severe than it was at the period in question, for the general climatic conditions of a country are measured, other things being equal, by the amount of its elevation above the sea-level.

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[1] Carl Vogt, *Nordfahrt.*

This is an elementary inference which seems to have escaped the champion of the Glacial theory, who. visiting Western Norway for the first time, or many times, and sailing or steaming in and out of its fjords, is struck, as every visitor is struck, by the smoothed and polished walls of rock he sees, by the rounded and mammillated appearance of the low islands he passes, and is disposed to break out into magnificent rhetoric on the subject. The facts are plain enough, their explanation is not so plain. To *the Glacialist* freshly arrived from England, or perhaps Scotland, full of icy enthusiasm, there could be no plainer proof of ice-action on a gigantic scale than these polished and smoothed walls and rounded bosses of crystalline rocks.

To the sceptic and the Philistine, the natural promptings of a heretical mind are to try and discover some other area where the same conditions occur, and where the story is more plainly written, and he naturally turns to Greenland, another rising land, where the polishing and rounding are of exactly the same kind; but, inasmuch as the movement of the land is more rapid, the story is clearer. In Greenland and in the archipelago of islands north of America, we have, as I say, precisely the same phenomenon to explain, but there it has been explained, by those who follow inductive methods, not as the consequence of an Ice Age, but as the result of recent submarine submergence and the continued beating and wearing and washing of the rocky surfaces of a rising land, assisted possibly in part by shore-ice and the movement of ice hummocks and gravel, etc. These are causes which would certainly produce the effects presented by Western Norway, and which have been attributed to a hypothetical ice-sheet. This is not all; these are the results which must inevitably have followed from the considerable submergence of the Scandinavian peninsula, which is not hypothetical at all, but which is one of the best established conclusions in geology.

This being so, I claim that the attribution of this polishing and rounding of the surfaces of Western Norway, which have been so generally and widely accepted as proofs of the former existence of a great ice-sheet, is not well founded, and that this hypothetical ice-sheet has had to do with this particular phenomenon as little or as much as the west wind has. The fact is, that these polished and rounded surfaces, when they occur on the coasts of Norway, on the islands off its shores, and in the Lofoden Islands, and up to a certain point only, are the measure, not of the potency of a former ice-sheet, but of the amount of submergence to which the land has been subjected in quite recent geological times. I am not the first to make the observation, although I press it further than Pettersen did. That well-known Norwegian geologist, who probably knew this coast better than any other Scandinavian geologist, urged over and over again that certain mammillated surfaces and polished walls of rock in Norway are clearly and definitely the result of marine and tidal action, precisely similar to that going on wherever crystalline rocks are subjected to the washing of the sea, and nothing more. This is surely a very important and useful conclusion, and one which decapitates many exotic adjectives which have found their way into the literature of the Ice Age, and takes away one of the most potent props of that very ricketty cripple the North Sea ice-sheet, for it makes the Northern peninsula an even more inadequate nurseryland of great masses of ice.

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[1] Keilhau, Bull. Soc. Geol. France, 1st ser., vol. vii.

It is perfectly plain that this rise of the Norwegian lands was shared by that of Sweden, Lapland, Finland, and Northern Russia. We have an immense quantity of evidence all pointing most emphatically to the rise having taken place all round the Northern Baltic seaboard since the so-called Glacial age, and evidence of it is forthcoming from all parts of Sweden and Finland in the widespread beds of stratified sands and clays which are found at various heights up to 1,500 or 2,000 feet, and in the shell-beds and other similar débris, and which show that not only has Scandinavia been rising for a long time, but also that it was not long ago in great part submerged, and formed part of a wide-spreading sea extending from the Dovrefelds to the Petchora.

Perhaps the most striking proof of this is the evidence of the fauna of the great lakes of Sweden and Northern Russia, *Relikten seen* as they have been called. They contain a number of species of animals clearly of marine types, curious biological witnesses to the fact of their having in recent geologic times formed part of a continuous sea. This must have been the very last chapter in their history, or these forms of life would have been exterminated.

Dr. Ludolf Credner has collected some very important evidence in regard to this matter in his well-known memoir on *Relikten seen*, published as one of the supplements to Petermann's "Mittheilungen" in 1887. He has shown that in thirteen Swedish lakes, namely, Wener, Wetter, Mölletjärnet near Krokfors, Leläugen, Stora-Lee-Sjön, Ånimmen in Dalsland, Glassfiord, Fryken in Wermland, Möckeln, the Mälar, Laxsjön, Barken, and Velangen near Upsala; in six Norwegian lakes situated to the east of the Dovrefelds, namely, Mjösen, Tyrifjord Af-see on the Dovrefeld, Sogusvandent and Eivvaugen near Christiania, Hurdals and Stor Sjön in Odalen; and twelve lakes in Northern Russia and Finland, namely, Ladoga, Onega, Höytiäinen, Pyhäselka, Rebja, Uleâtrask, Saimâ, Kalavesi north of Frederikshamm, Maaninga, Päljänne north of Helsingfors, Pielesjärvi north-west of Ladoga, and Nasijärvi—there are now living a number of marine forms which point most forcibly to all these lakes having once formed part of the ocean.

These consist of a seal (*Phoca annellata*), which occurs in several of the Finnish and Russian lakes, including Ladoga, Onega, and Saimâ; a number of Crustaceans, including *Mysis oculata, Pontoporeia affinis, Pallasca cancelloides, Gammaracanthus loricatus, Idotea entomon, Cythere lacustris*, and *Limnocalamus macrurus*; and three varieties of fish, namely, *Cothis quadricornis* and two forms of trout, which have become differentiated, apparently, from not now having access to salt water, namely, *Trutta Salar* var. *relicta*, and *Trutta lacustris* (op. cit., pp. 45–8). The greater part of these forms are Arctic ones, and point to the widespread mother sea of these various lakes having been connected with the Arctic Ocean. The lakes do not stand alone. The country in various directions is marked by beds containing Arctic marine shells, clearly proving a very recent submergence. In the north, says Credner, in Dalsland, Vermland, Dalecarlia, Gestrikland, and Helsingland, these beds exist to a height of 500 to 550 Swedish feet above the sea-level; in the south of Sweden they are not found so high; in Scania at 100 feet; in the neighbourhood of Lake Finga at 200 to 250 feet; near Braninye, near the southern point of Lake Wetter, at 700 or 800 feet; and he urges that up to this height Sweden has, since the Glacial period, been covered by the sea. The proofs do not merely consist in loose beds. Brongniart long ago described finding a surface of gneissic rocks at Uddevalla at a height of 200 feet above the sea-level, with barnacles (*balani*) adhering to the rocks, showing that the sea had remained there for a long time; and Lyell himself reports how in 1834 he found at Kured, about two miles north of Uddevalla, and at a height of more than 100 feet above the sea, a surface of gneiss newly laid open by the partial removal of a mass of shells, and so firmly did the barnacles adhere to the gneiss that he was able to break off portions of the gneiss with the shells attached. The face of the gneiss was also encrusted with Bryozoa. (Lyell's "Principles," ed. 1868, ii, 192.)

Another class of evidence is afforded by the so-called giants' cauldrons. For some reason or other these have been connected with glaciers and ice-sheets. I know not why. It is as plain as can be that they are the result of water in motion acting upon arrested stones, which are set spinning or turning round and thus erode deep holes; and wherever found they bear testimony to the more or less continued flow of water, and have nothing whatever to do with ice or its handiwork. They have been described as occurring in various parts of Sweden, and from their position attest the great alterations of contour of the country since they were made.

Bergmann, in the last century, mentions six as occurring at Kokare Fiarden, in Finland. One of them was still under water of a foot deep, and was only thirty years old when he wrote, and its actual growth had been watched by Nordenskiöld; and he urges that others of a similar kind, out of reach of the present streams, had the same origin. He mentions others in Jemteland, in West Gothland, and in Bohuslan. Sefstrom also describes these giants' cauldrons, or Jättegrytor as the Swedes call them, and points out that they are made by our present rivers, such as those near Avesta; and tells us that he himself saw some uncommonly beautiful ones some years before, while they were digging the canal on the side of Ostra Dalefven. Near Gagnefs Grada several of these cauldrons were met with, some large enough for a person to stand in. They were situated where a river formerly flowed down a slope. Others are mentioned as existing on the side of a hill near Stockholm between Roslagstull and Albans, apparently quite out of the route of any now possible river or stream. A famous one, in which several people can sit, exists on the mountain above the present falls of Trollhältan, and was therefore made by water when the contour of the country was entirely different to what it is now.

Let us now turn to another kind of evidence. This was adduced by that very acute observer Durocher, and accepted by Murchison, namely, the composition of the sand which forms such a notable part of the surface beds of Scandinavia. Durocher observed and described large horizontal tracts of sand in which only the quartz-grains remain, the mica and felspar of the original matrix having been in a large measure dissolved and washed away, a condition of things only to be explained by aqueous causes, and quite different to the sands due to the disintegration of granite *in sitû* either by ice or other means. This submergence seems to me to be completely confirmed again by the shape and contour of the surface of these northern lands: the rounded, whale-backed or mammillated surfaces, polished and smoothed, the rolled and rounded boulders, the polished pebbles in the gravels—all these are precisely paralleled by the phenomena reported by the Arctic navigators as marking the surface of the North American Archipelago, and that part of the northern shores of the continent which we know has only just emerged from the sea, and it seems to me we must attribute them to the same cause.

That this movement is shared by Finland, is also well known; and there also we have the same kind of evidence, except that marine shells are very scarce; but as an old writer says: "It is impossible not to perceive that the top of every rock *in sitû*, every tor, every hill and knoll of granite, or primitive rock, from Carelia to the Gulf of Bothnia, presents a surface as distinctly rounded and water-worn as the boulders or colossal pebbles that lie around their bases."

Durocher described long ago the wide stretches of rudely stratified sands which he met with in Finland, and which are only consistent with aqueous action. The most experienced and recent authorities in Finland, such as Nordquist and R. Hult, are of one mind about it. The former speaks of an Arctic sea which covered the greater part of Scandinavia, Finland, and Northern Russia (see Zool. Anzeiger, nn. 254–5); and the latter, in a recent geological memoir, collects the evidence for the recent submergence of Southern Finland, especially the country round Helsingfors; while Credner, whose prejudices are all the other way, is constrained to say: "*Indessen, so bestimmt aus Zahlreichen Anzeichen auf eine früher umfassendere Wasserbedeckung Finlands geschlossen werden muss.*" ("Relikten seen," part 2, p. 14.)

I would therefore urge that the recent history of the Scandinavian peninsula and Finland is the rise of the whole country from a condition in which a large portion of it was under the sea, until it became dry land as at present. This view has forced itself on everyone who has examined the country on the spot, and was held as much by Lyell and C. Martins as by Sefstrom and Durocher, by Credner and Erdmann. If so, it follows, it seems to me, that the climate of Scandinavia and its borders, like that of Greenland, instead of having become milder, has become more severe in these later times; and we can hardly doubt that when Scandinavia formed an archipelago of islands, constituted by those portions of it which are still unworn and unweathered and surrounded largely by water, those islands, instead of having been the nursery-ground of snow-sheets and icebergs or of glaciers much larger than those now existing, had a very different climate indeed, the land having been probably the home of trees, and the sea full of molluscs, etc. I cannot see how and where we are to find room or place between this condition of things and to-day for an Ice Age, with its portentous machinery. If there ever were an Ice Age in Scandinavia, therefore it was before this submergence, and not after it; and the majority of the champions of such a period, when the greater part of the country is supposed to have been blanketed in ice, put it in fact on the other side of this submergence. They claim further that before the land was covered by the sea it stood at a probably much higher level than it even does now, and was consequently capable of nursing a great ice-sheet. Of direct evidence of this former higher level of the land, I know none whatever. It is a postulate entirely created to meet the exigencies of the ice-men, and is completely arbitrary, and until evidence of it is forthcoming it ought to be erased from our books.

To Erdmann, the latest Swedish authority on the Ice Age, the beds which especially attest the action of ice in Sweden, and which he styles morainic, are not those formed of rounded pebbles, which he naturally assigns to the action of water, but the so-called angular gravel and the angular erratics. First let me remark that these beds of angular gravel have no resemblance whatever to moraines in their external appearance. They are not arranged in mounds, concentric or otherwise, but are laid down in continuous mantles, quite unlike all glacier beds known to me, nor are their contents in the least like ice stones. Again, Durocher long ago showed that the greater part of the Drift of Scandinavia has not been derived from the Dovrefelds and the higher lands between Norway and Sweden, or from Lapland, but from the much lower grounds of Central Sweden. He says distinctly that the mineralogical structure of the Scandinavian blocks found in South Sweden and in North Germany shows that they came from the low and mammillated hills of Sweden and Finland, and not from the higher mountains. Those mountains are schistose, while the greater portion of the blocks are granitic, and granite occurs in those mountains in only very small quantities. (Bull. Soc. Géol. France, 1846, pp. 64–5.) He thus objects to the theory of Murchison and Verneuil that the erratics were derived from the lands projecting above the ancient Northern Sea, whose existence everyone admits, and that they were carried away from them by icebergs, and thus floated over the water. This latter view seems quite untenable in the presence of the fact attested by Durocher.

(*To be concluded in our next Number.*)

IV.—LOW-TIDE CAUSEWAYS.

By the Rev. EDWIN HILL, F.G.S.

I SUPPOSE that most of us are familiar with the processes by which necks of land are cut down, by which promontories are turned into peninsulas, and the peninsulas into islands, while the islands in their turn become rocks. I have elsewhere called attention to all stages of the process as shown in the four corners of Sark. On the south there is the Coupee causeway, an isthmus 200 feet above sea-level, with a crest only some six feet in width; on the north, an isthmus yet lower, and parts beyond already being separated by the sea; on the west, an island, Breqhou; on the east, rocks, the Burons. There are to be seen all stages of the process, but does that process always proceed through all those stages to the end?

Many years ago, one in a party of frolicsome youths, I swam with them to an islet in a lonely Scotch loch. We intended to explore the unexplored, for there was no boat on the loch. We were, however, rather disappointed by the discovery that this apparently inaccessible islet was really joined to the land by a submerged ridge scarce under water; we need not have swum, for shallow wading would have sufficed. Since then I have frequently noticed such bars similarly joining rocks or islets to a neighbouring mainland; I have noticed them not only in such fresh-water lochs, but on the coast of the sea as well. Such, for instance, are the connections, passable at low tide, between the Jersey beach and Elizabeth Castle in St. Aubin's Bay; between Guernsey and Lihou, formerly also the access to Castle Cornet; there are many others, less conspicuous, in the Channel Islands. For all these, I think there is the same natural origin.

The cutting down of an isthmus is accomplished sometimes by springs, but generally by atmospheric agencies; by wind, by rain, and by frost, the mightiest of all. But all these lose all their power when once the surface is brought down below water-level, for then, though springs may still issue, they no longer flow down channels; rain and wind then spend their force on the water; frost must be fearful if it makes a foot in thickness of ice. Then, indeed, a new set of erosive actions may come into play—waves, tides, currents. In lakes, however, waves are feeble, tides and currents generally absent; so in such cases the subaqueous bar will last indefinitely. Even on the sea the like may happen in sheltered places, such as fiords, gulfs, or deep bays. In exposed situations where waves are violent, and tides or currents strong, the process of destruction will continue, as it is continuing in Sark. Yet sometimes even in exposed situations, destruction may be delayed or arrested. On shores where much material is being carried along the coast, that is, in places where a groyne would arrest sand or shingle, there such a bar may also arrest them, and instead of being destroyed, may itself accordingly actually grow. A well-known example is the Chesil Bank. (An interesting and valuable paper by Mr. Wheeler, reviewed in GEOL. MAG., January, 1897, p. 44, should be consulted in reference to this motion of shingle.) Accordingly there is a natural tendency in many situations for bars or causeways to form, at or near the water-level, connecting islets or rocks with the mainland.

These considerations have some bearing on the force of two arguments adduced in two controversies of old standing. When discussing the antiquity of the present sea-level along the English Coast, it has been argued that the causeway to St. Michael's Mount and the low-tide access to Holy Island have remained unchanged since our earliest records. But the considerations of this paper show that upheaval or depression might be going on and yet these connections suffer no visible alteration through many centuries. Again, in the discussions on the Parallel Roads of Glen Roy, etc., their coincidence with various cols forms a strong argument in favour of the Ice-Dam-Lake theory, and against the theories of submergences. According to that theory, a glen, dammed at its mouth by ice, would fill with water to the level of a col, but at that level the rising waters would find an exit over the col; the col level would therefore fix the shore-level, so that a road should agree with a col. But on the opposing theory of submergences, why should the resulting shore-lines chance so regularly to coincide with the cols? This argument is very strong. Yet the considerations of this paper show that there would be some tendency for a col to be cut down to the sea-level and no further; to become as one of these bars; and so to coincide with a shore-line. These considerations, therefore, to some extent weaken that powerful argument. It is remarkable that Nicol and J. F. Campbell, who both discuss the coincidence of the beaches with the cols, seem neither to have noticed this point.

V.—The Dry Lakes of Western Australia.

By Harry Page Woodward, J.P., F.G.S., Assoc. M. Inst. C.E., F.R.G.S ;

Honorary Consulting Geologist and Mining Engineer to the Colony of Western Australia.

UPON glancing at the map of Western Australia, the eye is at once attracted by a series of large lakes in the interior: which are further often emphasized by being coloured blue. The natural inference is, that they represent sheets of water, either fresh or salt.

Now if these lakes contain fresh water, the surrounding country must be almost a paradise; and if salt, still the evaporation from them would cause the atmosphere to be humid, and hence there would probably be heavy dews or light showers of rain all the year round. But this is not the case, the map being entirely misleading, and no Government should continue to reproduce these incorrect charts: for in the first place, they are not lakes in the accepted sense; and in the second, they are not correctly mapped in; for in one instance alone, that of Austin Lake, the Island (where many a promising mine is being worked at the present time) is represented upon the maps as a sheet of water five miles wide. The reason for this discrepancy is that these lakes were invented by the early explorers, and have never since been altered upon the maps. This island is about one and a half miles long, and rises abruptly from the lake-bed to a considerable elevation—in fact, being one of the highest ridges of the district. It is divided both from the north and south shores by narrow boggy channels, each of which is about 400 yards in width, whilst from its high point no extensive lake is visible, but only a number of very shallow depressions fringed by sandy ridges. These are not lakes in any sense of the word, but a series of salt clay-pans which drain one into another, and thus in very wet seasons they serve to carry off the surface water; but since the fall of the ground is so slight, and the surface presented for evaporation so great, this water never finds its way to the sea.

To understand this so-called Lake District thoroughly, one must realize that the interior originally consisted of a large tableland about 2,000 feet above the sea-level, above which here and there rose low range-masses or ridges of hard hornblendic rocks, or bosses of granite, which are the fundamental rocks of the district. These rocks, now that denudation has exposed them, are seen to run in belts (often of considerable width) in a north-westerly and south-easterly direction; but whether they outcrop or not, their strike can be traced by the nature of the superficial deposits, which are the result to a great extent of their disintegration.

The present configuration of the surface may be described as due to belts of high sand-plains, while here and there in hollows, or around the margins of the more elevated areas, one meets with outcropping bosses of gneissic granite, which rock is found everywhere to underlie these high sand-plains. More or less parallel with these, are areas of depression, in which the surface is for the most part covered with sand, loam, or clay; whilst from these valleys rise steep rocky ridges consisting of hornblendic schists, diorite dykes, and quartz reefs, which compose the auriferous series.

These valleys form the main drainage of the country, which falls in a south-easterly direction, but so gradually, that the rain-water, instead of cutting out a channel, spreads out in a broad sheet over the flat surface, thus forming, during a wet season, a series of large but extremely shallow lakes.

The water shed from the adjoining hills naturally, in rushing down their sides, carries with it not only such soluble salts with which it comes in contact, but also a certain amount of clayey matter, which is spread out in a thin layer over the plain, whilst the salts held in solution are deposited as the water evaporates, the result being the formation of numerous large salt clay-pans which have incorrectly been called lakes. These clay-pans, for the most part, run in chains, and are connected by channels—the whole being fringed by blown sandbanks containing a large quantity of gypsum, and upon which nothing but salt herbage, such as salt-bush, samphire, and mesembryanthemums, will grow. The beds of these pans are for the most part composed of a thin layer of clay, which rests directly upon the upturned edges of the highly inclined decomposed schists beneath. In other cases, the covering of clay is entirely wanting, the floor being apparently formed directly by the planed-down edges of the indurated rock, which is often strewn with fragments of quartz, whilst here and there huge reefs of this mineral outcrop at the surface.

When these lakes occur in hilly country, they generally cover the entire valley; but when on the open plain, they are fringed by æolian deposits, which often resemble coastal sand-dunes; whilst in other cases, where hills occur upon one side, the rocks of which are of a highly decomposed nature, these latter are found to be eroded in such a way that they form nearly vertical cliffs. Again, in the northern portion of the field, where these lakes are met with in tracts of country, the surface of which is covered by a deposit of indurated ferruginous clay (cement), they are surrounded by nearly vertical cliffs of kaolinized schists, capped by the above-mentioned recent deposits. In this class of country also, branches of these flats run off from the main valley, which gradually split up into canyon-like watercourses called "wash-aways." Immediately after heavy rain is the only time that the surfaces of the lakes may be seen covered by a few inches of salt water; and, in rare cases, even by a few feet when some obstruction to its flow has occurred. It must, however, be borne in mind that these remarks do not refer to the small fresh-water swamps and clay-pans, always spoken of as lakes, but to those large areas which are marked upon the plans as such.

As before stated, there is not sufficient slope in the surface of the country or a large enough rainfall to form rivers; also the surface-area exposed to evaporation is too great to allow any of the water to flow away; therefore, not only is there a thin layer of sediment deposited upon each occasion that these flats are covered by flood-water, but also a quantity of salt.

It would be only natural to suppose that in countless ages, these deposits would assume a considerable thickness; but this is not the case, for do we not in many places find the upturned edges of the very oldest known rocks forming the beds of these lakes, and where they are covered, it is only by a thin deposit of clay. After looking into the reasons for this, we first notice that the salts deposited upon these surfaces consist very largely of gypsum, which upon crystallizing out in the clay causes it to split up, thus allowing the weather to act upon it, which quickly converts it into an almost impalpable powder, which the wind distributes far and wide over the surface of the country, whilst the sand and heavier particles are blown along the surface until they meet with some obstruction, where they accumulate to form sand-dunes, hills, and ridges.

It will naturally be asked why, if these lake-beds are formed by wind and not by water, they should assume such a dead level. The answer to this is—that the subterranean water is always so near the surface that the moisture rising from it by capillary attraction holds together the particles, thus preventing either the superficial deposits or the disintegrated rock below a certain level from being removed by the wind.

The formation of the cliffs around these lakes would probably start in the same manner that the "break-aways" are being formed at the present day, viz.: by the action of the water thrown from the hard impervious cement-hills, which has not only cut out the canyon-like channels through them, but also into the decomposed rocks below to the lake-bed level. The resulting débris from this source, as well as that which falls periodically from the cliff-faces, must then have been removed by the wind, because no trace of it remains upon the clean-swept rock-bottomed lake-bed. This action goes on year after year. The rain falling upon the surface of the ground dissolves out the salts which the water carries in solution, together with the insoluble sediment in suspension, redepositing them upon these plane surfaces where they dry, and efflorescence being possibly added to by a small portion of the disintegrated rock-surface of the bed itself, this fine material is again scattered over the surface of the land by the wind.

Thus the country remains salt, since no streams carry away the saline matter to the sea, whilst the underground percolation of the water is so extremely slow that in millions of years no appreciable difference in its saltness seems to have taken place.

The subterranean water beneath these lake-beds is abundant and extremely salt, often containing as much as forty ounces to the gallon, but it varies considerably in quality, for the further a well is removed from these salt clay-pans, and the higher the elevation attained, the fresher the water becomes; thus, beneath the high sand-plain, or the elevated pervious caps of disintegrated granite, perfectly fresh water is often met with because from them the salts have been completely leached out, whilst they are not resupplied, since their distance from the lakes is too great for the wind to carry the salt. That salt is conveyed in this manner, is clearly proved in many places where granite rocks outcrop in close proximity to salt lakes. Upon these rocks, holes and depressions are met with, in which any rain-water that may fall is caught; and it was from this source that the original explorers and prospectors obtained a supply of water. It was always considered a certainty that such water would be absolutely fresh, being in fact pure rain-water, but there are exceptions to this rule, for at one place upon a rock, which rises at least 400 feet above the lake-bed level, a flat rock hole was found to be quite salt, in spite of the fact that it held only a few hundred gallons, and was thoroughly washed out and replenished with each fall of rain. It is clear, therefore, that the salt was first blown upon the rocky surface, and then dissolved and carried by the water into the rock hole, since there is no other source from which it could have been supplied.

It will be seen from the above that the so-called lakes have no claim to that title, but are merely salt wind-planed flats; and that they do not exist in reality as depicted upon the maps; therefore it is high time their name was changed, since it is most misleading; and further, all map publishers should cease to represent them by a symbol which conveys the idea that these dry æolian flats of Western Australia are lakes filled with water.

REVIEWS.

I.—PAPERS AND NOTES ON THE GENESIS AND MATRIX OF THE DIAMOND.

By the late HENRY CARVILL LEWIS, M.A., F.G.S., etc. Edited from his unpublished MSS. by Professor T. G. BONNEY, D.Sc., F.R.S., etc. Large 8vo; pp., including index, 72. Two plates and illustrations, chiefly of minerals, in the text. (London: Longmans, 1897.)

THE late Professor Carvill Lewis is best known to English geologists from his work on the glacier formations of our country—work which has been eminently suggestive of new interpretations, and which a particular school of glacialists has not been slow to utilize. On the other hand, as a Professor of Mineralogy in the Academy of Natural Sciences at Philadelphia, we must regard him as having been well qualified to investigate the interesting phenomena presented by the diamond-mines round Kimberley. This work was in a great measure based upon specimens shown and information obtained at the Colonial Exhibition in South Kensington as long ago as 1886, when the De Beers mine had perhaps a depth of 500 feet. It is true that mining operations have now extended to a depth of 1,500 feet, and thus it might be thought that Professor Lewis' papers are a little out of date. Excepting, however, that the main mass of the diamond-rock is harder and less easily disintegrated, there does not appear to be such a difference between 500 feet and 1,500 feet as one might suppose, whilst in many respects the old quarrying system afforded more facilities for observation than underground mining.

Two papers were read before the British Association in 1886 and 1887 respectively, and abstracts of these were published. Hence, Sections I and II of the present work, representing those papers, are not wholly original; and, indeed, Lewis' conclusions have been quoted, notably by Mr. Sawyer, the Government Inspector of Mines, and possibly by other writers on the diamond-mines of South Africa. The history of a rock somewhat similar to that prevailing in the Kimberley pipes, which has been found at two localities in the United States, constitutes Section III of this posthumous publication.

The MSS. of these three papers ultimately came into the hands of Professor Bonney, who, at the request of Mrs. Carvill Lewis, has kindly undertaken to edit the whole. The two first papers are printed very nearly as they were left by Professor Lewis. The statements made and the results given represent his views in 1887, and, so far as the editor knows, at the time of his death (July, 1888). Of the third paper (Section III) nothing had been written, the materials consisted only of some very brief "jottings" and a small set of rock-specimens. The editor has drawn up a statement of the facts concerning them from such literature as he has found, adding brief descriptions of the structures of the specimens themselves. Some other material remained, from which data two additional sections were compiled, but it was finally decided to cancel them. In these (note, p. 68) the author insists on the intimate connection of peridotite (or serpentine) with the diamond at least in South Africa, and also in Kentucky.

Our readers will easily understand the fascination which such a subject as the diamond-rock of South Africa would have for a man of Professor Lewis' stamp. Truly, it is a rock *sui generis*, and the scientific interest attaching to it is only exceeded by its commercial value. The author, in quoting previous writers, does no more than justice to Mr. Dunn, who, as long ago as 1873, when many foolish speculations were in vogue, insisted on the "euphotide (?)," as he called it, being the *mother rock* of the diamond.

It may be that there was a little confusion at the time of Lewis' writing (1886–7), between the rock described in Section I and that described in Section II, the one without diamonds, the other diamantiferous. Nothing can be more certain than that the real diamond-carrying rock of the Kimberley district is a medley or mixture, and in that case is scarcely entitled to a specific name, such as "Kimberlite," bestowed by the author. "Kimberlite proper," he tells us subsequently (p. 51), "is a typical porphyritic lava"; yes, but without diamonds. This, we apprehend, is the rock described in Section I as "Hard Wack Floating Reef," and is the same rock as that familiarly known as the "snake" of De Beers mine, a winding dyke of igneous rock varying in width, which Mr. Williams, the General Manager of the De Beers Company, supposes to be a younger eruptive formation coming from the same volcanic source as the "blue ground." Olivine is the main ingredient of this rock, the principal accessories being enstatite and biotite. It would have been satisfactory if a detailed examination of this rock had been given, since it most probably represents, to a considerable extent, the original peridotite, which bursting through the carbonaceous shales of the Karoo beds, at intervals, has supplied a large portion of the mixture, with a serpentinous base, known as the diamond-rock, or as Lewis would call it "Kimberlite breccia."

The actual diamond-rock itself, being so much of a mixture, the mineralogical details given in Section II are of less importance, since it is difficult to determine which minerals are endogenous and which are derivative. Most of the minerals described, including the diamonds, Lewis seems to have regarded as endogenous. We can easily believe that chrome-diopside, smaragdite, bastite, magnetite, chromite, ilmenite, and picotite, said to be common under the microscope, represent paragenetic minerals of the orginal peridotite, as also perofskite, said to be the most abundant titanium mineral of ultra-basic rocks. The same may also be said of the peculiar brown biotite (altered to vaalite) and abundant specimens of pyrope. When we bear in mind, however, that Moissan is said to have detected more than eighty species of minerals in the "blue ground," or diamond breccia, we can well believe that many of these are derivative.

The minerals described in Section II are said to lie, some of them porphyritically, in a base which is a more or less homogeneous serpentinous mass containing fragmental enclosures, of which shale is the most abundant. The fragments of shale have lost their shaly character together with their carbonaceous matter, a result, he considers, of alteration through the heat of the lava. It should be noticed, in this connection, that local writers have usually spoken of the shale in the diamond-rock as not being fused at the edges. As regards the composition of the ground-mass, after eliminating from the calculation the very considerable quantity of calcite, he concludes that one-half consists of serpentine and the bulk of the remainder of olivine.

Let us now see how far the editor assists us in comprehending the diamond-rock of the Kimberley district. Plate i is an effective picture of a fragment of the diamond-rock of De Beers mine, from rather over 1,000 feet (obtained by Stone in 1894). This presents a pseudo-porphyritic appearance: the largest inclusion, nearly a couple of inches long, consists of rather decomposed compact serpentinized olivines and pyroxenes, with a few flakes of mica. In plate ii (1) a slice of this rock is magnified twenty-two diameters; crystals of mica and altered enstatite are seen with several grains of serpentinized olivine, whilst the separate mineral grains decrease in size until they become indistinguishable from the granular matrix of serpentine, calcite or dolomite, iron-oxide, perofskite, etc. We may well believe with the author that, in his time, there was no named rock type having at once the composition and structure of the Kimberley rock. But, bearing in mind that the diamond-rock is essentially a mixture, the name "Kimberlite," as applied to this rock, though it may be convenient as a mere designation, can scarcely possess any scientific value.

The so-called porphyritic brecciated structure Lewis attributed not to pressure, but to mechanical disturbances during and after cooling, and according as the porphyritic or brecciated structure predominated so did people differ in their opinion as to whether it was a lava or a tuff. He assigns nine reasons why it should be a true igneous lava, and not a mud or ash. In this respect he had in mind the mud volcano theory which was held by Erskine. Certainly the diamond-rock itself is not exactly a true igneous lava, whatever portions of it may have been; but the "floating reef" and "snake" of De Beers, which Lewis probably would call "Kimberlite proper," better retain the character of igneous erupted masses. These unfortunately are not diamantiferous.

There can be little doubt, as long ago pointed out by Chaper, that these pipes bear the marks of several eruptions, as of course must have been the case in volcanic necks. There is nothing in this which should cause the Kimberley pipes to differ from other necks. It is the presence of diamonds in association with broken-up peridotites which constitutes at once the interest and the peculiarity.

Specimens from two localities in the United States, described in Section III, are said to bear a close resemblance to the diamond-rock of South Africa. These are peculiar peridotites, which, in spite of so much of the structure being secondary, preserve the shape of crystals, olivine and enstatite being the most conspicuous together with the peculiar brown biotite already mentioned. These rocks occur in dykes which have been forced through beds of Carboniferous age: they contain fragments of shale, and now consist mainly of serpentine with a considerable proportion of carbonates. Plate ii (2) is a magnified section of a portion of one of the American rocks, the matrix consisting of granules of serpentine, iron-oxide, perofskite, etc., along with crystals of biotite, as in the Kimberley rock, whilst the grains are mostly olivine in various stages of change. The editor remarks that the specimens, both from New York State and from Kentucky, are perhaps a little more like a porphyritic igneous rock than anything he has seen from Kimberley, owing to the absence of distinct rock fragments, and the more uniform size of the included minerals. No diamonds are found, but carbonadoes are said to occur in the Kentucky rock.

With respect to the Kimberley rock, the editor, whilst admitting that it differs from any rock, whether peridotite or serpentine, does not agree with the author in his conclusions as to its origin. Professor Bonney considers that the apparent glassy inclusions, "together with all the large minerals (not excluding the diamonds), are true 'fragments,' like the pieces of shale which are sometimes found associated with them, produced by the explosive destruction of more coarsely crystalline rocks of earlier consolidation, and not the result of a fluxional movement in a magma, which had previously reached a stage of partial separation and incomplete consolidation, and had in addition incorporated fragments of overlying rocks in its upward progress." But he allows that this interpretation would not necessarily affect his friend's views as to the genesis of the diamond, viz., by the action of an extremely basic rock upon carbonaceous material.

Although there seems to be a pretty general consensus of opinion that, in some way or other, a peculiar peridotite, invading carbonaceous beds, is the mother rock of the diamond, yet the evidence at present is by no means conclusive either as to the depth or the precise conditions under which this action took place. That the diamonds originated lower down than the position in which they are now found, is most probable, since the breccia in which they occur is more or less of a mixture which has been forced upwards. The evidence as to depth is somewhat contradictory; for, on the one hand, we have the fact that the several pipes have their own type of diamonds, a circumstance tending to indicate that the diamonds originated in each pipe separately, and not in a general reservoir. On the other hand, we have the fact that the area within which diamond pipes may be expected to occur is of wide extent, since the Leicester mine is forty miles from Kimberley and Jägersfontein sixty miles. This might be held as pointing to a general reservoir of diamantiferous rock seated at a great depth. On the whole it would seem that, although the peridotite may be widely distributed, at a great depth, the conditions under which it becomes diamantiferous are local and only occur in the pipes.

The chemical aspect of the question, though not dealt with in the present publication, has greatly changed since Professor Lewis wrote. For many years chemists looked upon hydrocarbons as the most promising material from which the diamond might have been derived, and laboratory experiments were conducted on this supposition. As bearing on this point, it is interesting to note that Roscoe by digesting the "blue ground" with ether obtained a hydrocarbon which was found to be crystalline and strongly aromatic, burning with a blue flame and melting at 50° C. (p. 51).

More recently, as is well known, Moissan and other chemists have actually obtained small diamonds by melting iron mixed with carbon in the electric furnace, and arranging the experiment so that the separation of the iron from the carbon takes place under enormous pressure. This reaction consequently is now regarded as the one most likely to have produced diamonds in nature. "It is certain," said Sir William Crookes, at a recent lecture before the Royal Institution, "from observations made at Kimberley, corroborated by experience gained in the laboratory, that iron at a high temperature and under great pressure will act as the long-sought solvent for carbon, and will allow it to crystallize out in the form of diamond—conditions existent at great depths below the surface of the earth."

Undoubtedly the fact that small diamonds have been made by the action of iron on carbon favours the supposition that this, too, may be Nature's process, and there is further corroboration in the fact that iron-oxide is the most abundant substance of the ash of

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iamond. Moreover, microscopic diamonds have been found in neteoric irons. Yet it must be regarded as a singular circumstance hat basalts far richer in iron than the Kimberley diamond-rock ave passed through beds containing carbonaceous matter, and ontain large masses of metallic iron which is not associated with iamond either at Kimberley or elsewhere.

It must be a matter of regret to geologists, and indeed to all men f science, that Professor Lewis was not spared to continue his nvestigations on a subject which presents so many points of interest.

I.—THE ANCIENT VOLCANOES OF GREAT BRITAIN. By Sir ARCHIBALD GEIKIE, F.R.S., D.C.L., D.Sc., etc., Director-General of the Geological Survey. Imperial 8vo. In two volumes. Vol. I, pp. xxiv and 477, with four maps and 175 illustrations. Vol. II, pp. xvi and 492, with three maps and 382 illustrations. (London: Macmillan & Co., Ltd., 1897. Price 36*s*. nett.)

(Second notice.)

(WITH PLATES XVI AND XVII.)

ALTHOUGH we have no "burning mountains" in England, and no evidence of volcanic action but such as belong to the emote past, yet a careful study of modern volcanoes and of the roducts of eruptions observed all over the world, has given us he key by which to interpret the ancient tuffs, lavas, basalts, gabbros, andesites (porphyrites), trachytes, pitchstones, felsites, hyolites, etc., which are met with in these Islands, and also to letect the old plateaux discharges of volcanic materials of Carboniferous age that now form broad tablelands or ranges of hills; or the puys, whose ejected materials formed cinder-cones or ava-domes and were confined to smaller areas round the centres of eruption, with occasional flows of basic lava, as admirably displayed in Central France. To these must be added the innumerable examples of dykes, volcanic necks, bosses, and sills, exposed by denudation, all of which have been carefully studied and classified.

With the ordinary type of modern, and especially of active, volcanoes, we need not here concern ourselves. The lofty cones of the Vesuvian type, with their widespread lavas and ashes, their vast craters, and numerous parasitic vents, can form no lasting record of volcanic action. Subaerial denudation, acting incessantly year after year, gradually planes down and carries away their unstable slopes, and if unchecked by any fresh discharge of volcanic material, degradation will at last have removed the whole cone. But whilst no universal rule can be laid down as to the relative durability of any rock, yet in the course of vast periods of time during which denudation and disintegration have been carrying on their destructive work, the older eruptive masses, consisting usually of the more durable materials, have at last risen into prominence, and now form some of our wildest scenery and the summits of our most craggy and spiry mountains. Among the many examples given, we cannot forbear to quote one illustration from the chapter entitled the "Influence of Volcanic Rocks on the Scenery of the Land," which is in Sir A. Geikie's most agreeable style—

"A contrast of another type meets us in the broad midland valley of Scotland. Around the city of Edinburgh, for instance, the landscape is diversified by many hills and crags, which show where harder rocks project from amidst the sediments of the Carboniferous system. On some of the crags the forts of the early races, the towers of Celts and Saxon, and the feudal castles of the Middle Ages, were successively planted, and round their base clustered for protection the cots of the peasants and the earliest homesteads of the future city. Beneath these crags many of the most notable events in the stormy annals of the country were transacted. Under their shadow, and not without inspiration from their local form and colour, literature, art, and science have arisen and flourished. Nowhere in short, within the compass of the British Isles, has the political and intellectual progress of the people been more plainly affected by the environment than in the central district of Scotland."

"When now we inquire into the origin and history of the topography which has so influenced the population around it, we find that its prominences are relics of ancient volcanoes. The feudal towers are based on sills and dykes and necks. The fields and gardens, monuments and roadways, overlie sheets of lava or beds of volcanic ashes. Not only is every conspicuous eminence immediately around of volcanic origin, but even the ranges of blue hills that close in the distant view to south and north and east and west are mainly built up of lavas and tuffs. The eruptions of which these heights are memorials belong to a vast range of geological ages, the latest of them having passed away long before the advent of man.

"But they have left their traces deeply engraved in the rocky framework of the landscape. While human history, stormy or peaceful, has been slowly evolving itself during the progress of the centuries in these fertile lowlands, the crags and heights have remained as memorials of an earlier history when Central Scotland continued for many ages to be the theatre of vigorous volcanic activity." (Vol. i, pp. 104, 105.)

The Puys.—As an illustrative example of the Carboniferous puys of Scotland, we give that of the junction of the amygdaloidal basalt with the shales and limestone half a mile east from Kinghorn, Fife. (Plate XVI.)

"When the puys began their activity, this district was gradually dotted over with little volcanic cones. At the same time it was affected by the general movement of slow subsidence which embraced all Central Scotland. Cone after cone, more or less effaced by the waters which closed over it, was carried down and buried under the growing accumulation of sediment. New vents, however, continued to be opened elsewhere, throwing out for a time their showers of dust and stones, and then lapsing into quiescence as they sank into the lagoon. Two groups of volcanoes emitted streams of lava and built up long volcanic ridges—those of Fife and West Lothian.

"The occasional presence of the sea over the area is well shown by the occurrence of thin bands of limestone or shale, containing such fossils as species of *Orthoceras*, *Bellerophon*, and *Discina*, which suffice to prove the strata to be the equivalents of the Lower Limestone shale and part of the Carboniferous Limestone of England" (pp. 463–4).

One of the most interesting features of the massive relics, left by denudation of ancient volcanic lavas, is to be seen in the Basalt-plateau of the "Parish of Small Isles," which includes the islands of Eigg, Rum, Canna, Sanday, and Muck.

"That the fragments of the basaltic plateau preserved in each member of the group of the Small Isles were once connected as a continuous volcanic plain, can hardly be doubted. Indeed, as already stated, they were not improbably united with the plateau of Skye on the north, and with that of Mull, Morven, and Ardnamurchan on the south. Taking the whole space of land and sea within which the basalt of Small Isles is now confined, we may compute it at not much less than 200 square miles.

"The most varied and interesting of the fragments of the basaltic plateau in the area of the Small Isles is that which forms the island of Canna, with its appendage Sanday. Canna measures five miles in length by from half to a mile in breadth, and consists entirely of the rocks of the plateau and their accompaniments. The basalts are exposed along the north coast in a range of mural precipices rising to a height of about 600 feet above the sea. From the top of the escarpment the ground falls by successive rocky terraces and grassy slopes to the southern shore-line. Sanday, connected with the large island by a shoal and foot-bridge, is two miles long and 220 to about 1,200 yards broad. Its highest cliffs range along its southern shore to a height of 193 feet, whence they slope gently northward into the hollow between the two islands."

The author had observed, as far back as 1865, an ancient river-channel, which, during the volcanic period, had been eroded on the surface of the basalt-plateau, and of which a small portion had been preserved under a stream of pitch stone-lava that had flowed into and buried it.

This watercourse was shown to have been excavated by a stream coming from the north-east, or east, and to be younger than the plateau-basalts of the district or even the dykes which cut the basalts. Yet that it belonged to the volcanic period was proved by the manner in which it had been sealed up and preserved under the black glassy lava of the Scuir. Other and more abundant evidence of river-action was brought to light by Sir A. Geikie, during his later examination of the islands of Canna and Sanday, belonging to an earlier part of the volcanic period. This evidence reveals that a powerful river, flowing westwards from the Highland mountains, swept over the volcanic plain while the sheets of basalt were still being poured forth, and while volcanic eruptions were taking place from cones of slag. In one spot, the former existence of an old land-surface is attested by the presence of some shaly layers, which have been deposited on a remarkable slaggy basalt; above these is a thin coaly parting enclosing a small tree stump still standing erect upon the coaly parting and shale, which in its turn is immediately overlain by and enveloped in a massive flow of basalt.

Again, "In the Creag nam Favileann (Seamews' Crag) and the gully that cuts its eastern end, likewise in the two singularly picturesque stacks of Dùn Mòr and Dùn Beag, or Big and Little Gull Rocks [Pl. XVII, Figs. 1, 2], which here rise from the foreshore, two distinct platforms of detrital material may be noticed among the basalts. Both of these can be well seen in Dùn Mòr, about 100 feet high [see Fig. 2].

"The lower band, four or five feet thick, is here a rather coarse conglomerate, which lies upon a sheet of scoriaceous basalt that extends up to the base of the Creag nam Favileann. It is directly overlain by another basalt, about 30 feet thick, which dips seawards and forms a broad shelving platform whereon the tides rise and fall. On this stack a second coarse conglomerate, about 10 feet thick, forms a conspicuous band about a third of the height from the bottom; it is composed mainly of well-rounded blocks of various lavas up to 18 inches or more in diameter, but it contains also pieces of Torridon Sandstone. It is covered by about 60 feet of basalt, which towards the base is somewhat regularly columnar, but passes upward into the wavy, starch-like, prismatic structure."

The story of Dùn Beag is still more interesting and remarkable, but in order to explain its structure properly one ought to have had at least three figures, figs. 272, 273, and 274; but those who are really interested will get the book and read it for themselves.

It is these and such like megalithic monuments which enable us to grasp the fact to what an enormous amount of denudation the old volcanic outflows must have been subjected. Referring to the effects of denudation Sir A. Geikie writes:—"The original height of the plateau of Mull is shown by the outlier of Ben More to have been at least 3,200 feet. If to this figure we add the portion of the basalt-group submerged under the sea, the height will probably be increased by several hundred feet. . . . . If, in the meantime, we suppose the present mean level of the plateau to be 1,000 feet above the sea, the difference between this amount and the assumed original height will be 2,000 feet. If, further, we take the present average rate of degradation of the Mull plateau to be $\frac{1}{6000}$ of a foot in a year, which has been shown to be probably a fair estimate, then the time required for the lowering of the Mull plateau from its original to its present average level amounts to twelve millions of years. Yet this period, vast though it be, does not carry us back even as far as the beginning of Tertiary time" (pp. 461–2).

"Among the broad features which soonest arrest attention in a survey of volcanic action is the tendency of volcanoes to range themselves along continental borders or in oceanic islands. This energy in Britain has shown itself along the western or Atlantic margin of the European continent.

"Moreover the volcanic rocks in Britain are ranged along the greatest length of the group of islands, in a general north-and-south line, from the south of Devonshire to the far Shetlands, and it is always on the western side of the country that they occur.

"A second and still more remarkable feature in the geological history of Western Europe is the persistence of volcanic activity along the site of the British Isles . . . . that from primæval time, vaguely termed Archæan, onward to that of the older Tertiary clays and sands of the south-east of England—that is to say, through by far the largest part of geological history, as chronicled in the stratified crust of the globe—this long strip of territory continued to be intermittently a theatre of volcanic action. Every great division of Palæozoic time was marked by volcanic eruptions, sometimes over tracts hundreds of square miles in area and on a colossal scale. After a long period of quiescence during the Mesozoic ages, the renewed outbreak of volcanic energy in older Tertiary time, so marked over the western half of Europe, reached its maximum of development along the Atlantic border from the north of England and Ireland, through the chain of the Inner Hebrides to the Faroe Islands, Iceland, and Greenland" (p. 467).

These are at best but samples, drawn at a venture, from the vast stores of valuable information which have been garnered in these volumes by their author. Under his guidance we may study the various forms and behaviour of eruptive rocks, whether uprising as lava-flows on the surface, or, when the vents of volcanoes became plugged up, the final efforts which have led to the intrusion of sills and dykes, not only into the rocks beneath the volcanic sheets, but also in many instances into at least the older parts of the sheets themselves. And we may learn how these subterranean manifestations of volcanic action may be seen and recognized in almost every district.

Nor has the nature of the volcanic products of eruptions been left unstudied or unrecorded, and the student may gather much as to the behaviour of eruptive rocks in the field on a large scale, and if their microscopic structure is not so extensively dealt with, yet sufficient is said upon microlites, perlitic and spherulitic structures, granophyres, dolerites, etc., to satisfy all but the most exacting and enthusiastic of petrologists.

In closing this notice of the Ancient Volcanoes of Britain we cannot fail to congratulate the author on the very splendid series of illustrations with which the pages of this admirable work abound. The maps and printing are excellent, and evidently the publishers have determined to make the book a complete success. Every geologist who can spare 36*s.* will secure a copy for his private library; every public library and book-club will order a copy; of course Mudie's will take several! and we venture to believe they will be read by many.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 23, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "Notes on a Collection of Rocks and Fossils from Franz Josef Land, made by the Jackson-Harmsworth Expedition during 1894–6." By E. T. Newton, F.R.S., F.G.S., and J. J. H. Teall, Esq., M.A., F.R.S., V.P.G.S.

A large collection of rocks and fossils, obtained by the members of the Jackson-Harmsworth Expedition, chiefly from the neighbourhood of Cape Flora, on the south-west of Northbrook Island, but also from more distant localities visited during boat- and sledge-journeys, have been sent to the Director-General of the Geological Survey, and examined by the authors.

After a summary of what was previously known of the geology of Franz Josef Land, an account of the new specimens is given. The rocks are for the most part basalts and are described in detail; they are usually formed of labradorite, augite, and interstitial matter which is sometimes represented by palagonite containing a large percentage of iron-oxide. This palagonite is regarded as the hydrated representative of the residual magma left after the separation of labradorite and augite; and the conclusion is reached that in this case progressive crystallization has resulted in the concentration of iron-oxide in the mother liquor.

Most of the fossils have been collected around Cape Flora. The presence of *Ammonites macrocephalus, A. modiolaris*, and *Belemnites Panderi* indicate the presence of rocks of Lower Oxfordian or Callovian age; while, apparently above these, a plant-bed was met with in which the genus *Ginkgo* (*Salisburia*) is conspicuous, and this is elieved to be of Upper Jurassic age.

The oldest fossiliferous bed yet found occurs about twenty miles to the west of Cape Flora, and also contains plant-remains, which, it is thought, may be Lower Jurassic and possibly of the age of the Great Oolite. The plant-beds and numerous indications of layers of lignite seem to show that these Jurassic strata are to a great extent of estuarine or fresh-water origin.

The general structure of the country appears to be typified by what occurs at Cape Flora, where cliffs of sedimentary strata some 600 feet high (for the most part hidden by talus) are overlain by 500 feet of basalt. At some other localities, however, the basalt is found at the sea-level.

It is pointed out that the islands which make up the archipelago of Franz Josef Land, are fragments of a formerly extensive region of plateau-basalts, similar to that of which the Færöe and the Western Isles of Scotland must have formed a part.

2. "Deposits of the Bajocian Age in the North Cotteswolds.—I. The Cleeve Hill Plateau." By S. S. Buckman, Esq., F.G.S.

This paper deals with a portion of the Northern Cotteswolds termed the Cleeve Hill plateau; and, like a previous communication on the Mid Cotteswolds, it is concerned with the deposits which intervene between the Upper Freestone and the Upper *Trigonia*-grit. The author shows that in the Cleeve Hill plateau there is, beneath the Upper *Trigonia*-grit, a further series of beds which have not been found elsewhere in the Cotteswolds, and by placing them in their order he is able to show the sequence of the Cleeve Hill "Inferior Oolite" rocks, about which there has been so much misconception. A map is given to show the positions of the different quarries, with notes as to the strata which they exhibit.

The paper also gives further information concerning the Bajocian enudation, and with it is presented a map showing the areas of he different rocks upon which the Upper *Trigonia*-grit reposes ion-sequentially. Notice is also taken of a water-bearing bed, and f its economic importance. Some remarks are made upon the ncient geography of the Cleeve Hill plateau in regard to streams. Their probable courses are marked upon a map.

3. "Pleistocene Plants from Casewick, Shacklewell, and Grays." 3y Clement Reid, Esq., F.L.S., F.G.S.

The plants from Casewick and Shacklewell were obtained by vashing two lumps of clay in the collection of the late Sir Joseph Prestwich. The species are few and call for little remark, except hat the climate was not Arctic. They are all common British orms.

The collection from Grays consists of leaves, already partly letermined by Gaudin and Heer, though unpublished, and some umps of clay, out of which the author washed a few seeds. The lora points clearly to a temperate climate and mild winters.

4. "An Explanation of the Claxheugh Section (Co. Durham)." 3y D. Woolacott, Esq., M.Sc. (Communicated by Professor G. A. Lebour, M.A., F.G.S.)

The section of which an explanation is offered in this communiation occurs about two miles west of Sunderland, and has been ioticed by Messrs. King and Howse and Professor Lebour. The ase shows the Permian Yellow Sands, which are succeeded at the vest end of the section by the Marl Slate, thin-bedded limestones, ind at the top crystalline limestones without any trace of bedding. At the east end the Marl Slate and thin-bedded limestone are absent, ind, except when a breccia intervenes, the crystalline limestone rests n the Yellow Sands, though the thin-bedded limestone and Marl Slate show no signs of thinning-out. There are also minor compliations. The author suggests that the section may be explained by upposing that denudation occurred in a cavern, the roof of which fterwards fell in, and that disturbances were also produced by creep"-movements.

CORRESPONDENCE.

THE ORIGIN OF THE GREY GNEISS OF ANGLESEY.

Sir,—In the debate at the Geological Society on April 28, when ny paper on the Grey Gneiss of Anglesey was read, some criticisms vere offered by the Rev. J. F. Blake, to which, with your pernission, I desire to make a brief reply. Had I enjoyed the good ortune to be present on the occasion, it would not be necessary for ne thus to trouble you.

To save your valuable space, I will confine myself to one point—he nature of the rock out of which the grey gneiss has been formed. This is a vital part of the question, and, if it be settled, much else will follow. In my paper I contended that the gneiss was originally a felsite. The Rev. J. F. Blake denied this. He admitted that "some eminent petrologists" had, on microscopic examination, pronounced the rock from which the gneiss has been formed to be a felsite; but he would not yield to their testimony. He had seen the rock in the field, and he "regretted" that these authorities had made a mistake. It may seem a little presumptuous for Mr. Blake to contest a determination made by three of the best petrographers in Europe; and we may suspect that if Ajax ventures to defy the lightning, Ajax will not do himself much good. Most people will consider that such an authoritative identification is absolutely decisive, and I, for one, assume it to be so. My main purpose in writing is, however, to point out that even the field-evidence, which, in Mr. Blake's opinion, refutes the "eminent petrologists," is dead against him. Within a hundred yards of the critical section at Y Graig, in which the felsite passes into the gneiss, a rock which closely resembles the felsite and which also graduates into a similar gneiss, is seen to penetrate the diorite, which is more or less altered, in numerous veins, some of which are branched. Thus the microscope of the "eminent petrologists" and the eyes of the field-observer who knows where to look, lead to the same conclusion. Mr. Blake himself admits that the rock thus shown to be a felsite "passes by insensible gradations into the ordinary grey gneiss." He says that the "phenomenon is a purely local one." This is a mistake, as I can prove by examples to the contrary, though the felsitic structure is nowhere, I believe, so marked as at Y Graig; but if it were so, my case is not materially affected. If felsite is converted into a typical gneiss at Y Graig, all *primâ-facie* objection to such a change disappears, and the field-evidence receives important confirmation. C. CALLAWAY.

TEWKESBURY.
May 11, 1897.

TRINUCLEUS SETICORNIS AND THE UPPER BALA BEDS.

SIR,—In the report of a discussion of a paper on the fauna of the Keisley Limestone, Part II (Q.J.G.S., vol. liii, p. 106), the author is stated to have made the following remark: "Mr. Marr . . . . denied that *Trinucleus seticornis* was specially characteristic of Upper Bala beds, though some years ago he had called the Upper Bala beds of the Haverfordwest area after that fossil." I should hardly have supposed that my words required an explanation, but as the speaker on that occasion appeared puzzled, I will give it.

Mr. T. Roberts and I (in 1885) called the Upper Bala beds of Haverfordwest *Trinucleus seticornis* beds, because the fossil or one of its varieties is particularly abundant in those beds *in that area*, and we did not there discover it in beds of Middle Bala (Caradoc) age. We were perfectly justified in our action, and there is precedent for it; e.g., no one supposes that the *Leda myalis* beds of the Cromer Forest Group are the only beds with *Leda myalis*. If we had spoken of the beds as constituting the zone of *Trinucleus seticornis* an explanation might be necessary, although I hold that even that would be admissible. I certainly supposed that all students of Lower Palæozoic geology knew that the fossil which has been determined as *Trinucleus seticornis* by Salter, Angelin, and many others occurs abundantly in Middle Bala (Caradoc) beds. If Mr. Reed will turn to my Sedgwick Essay "On the Classification of the Cambrian and Silurian Rocks" (published in 1883), where the Upper Bala beds are generally separated from those of Middle Bala age, he will find *Trinucleus seticornis* recorded as a Middle Bala fossil in North Wales (p. 39), the Lake District (p. 57), and Scandinavia (p. 76), and nowhere recorded in the Upper Bala list. Mr. Roberts and I used the term *T. seticornis* beds locally because we thought (wrongly it appears) that under the circumstances it could mislead no one.

In the above-mentioned discussion I disputed the statement that *T. seticornis* was a characteristic Upper Bala fossil, as the form which is usually taken as *T. seticornis* occurs, as remarked above, in Middle Bala beds. I have not seen Hisinger's original specimen, and have been unable to obtain access to a copy of the later (1840) edition of "Lethæa Suecica" in which the form is figured. If Mr. Reed has examined Hisinger's specimen, and can prove that the reference by Angelin, Salter, Linnarsson, Törnquist, Tullberg, and others of the common Middle Bala form to Hisinger's species is erroneous, I will cry "Peccavi." I am quite prepared to believe that there is a characteristic *Trinucleus* in the Upper Bala beds, but doubt whether it is Hisinger's species. I should not be surprised if the variety *Bucklandi*, amongst others, be eventually proved characteristic of these beds.

There are many statements in the body of Mr. Reed's paper on the Keisley Limestone with which I regret that I am unable to agree, but I do not wish to trouble your readers with questions of detail, especially as I am given to understand that the fauna of the Keisley Limestone is about to be examined by a very competent palæontologist. JOHN E. MARR.

CAMBRIDGE, *July* 15, 1897.

ON THE ORIGIN OF LYNCHETS.

SIR, — Mr. E. A. Walford's article, which attempts to give a natural origin of lynchets, based on geological conditions, is not very convincing, and seems indeed to refute itself. Had he seen the many perfect examples which the Chalk Downs afford, I think he would never have suggested a natural explanation for lynchets. Joining the high road from Amesbury to Salisbury and close to the Workhouse are some very typical lynchets, all in the Upper Chalk, and yet confined to only a very small portion of it; yet, if geologic conditions are the cause, they should occur in many other localities of the Chalk area. The opponents of the artificial origin must prove why they are confined to small areas when the geologic conditions, which they consider as the cause, occur over wide areas.

Taking the Amesbury examples as typical ones, they will be seen all to start from one straight line drawn about the middle of the slope, and to end, diminishing gradually in width, on the steep side of the slope. Their ground-plan also is *always* the same, and that is the shape of the blade of a scythe, and they end against one gradual curve, viz., the steep side of the slope, and are as nearly one size as the shape of the slope will allow.

When they occur on the slopes of escarpments and run along combes, these terraces will be seen to be parallel with the sides of the combe; and yet when they occur on the spur or slope separating two combes they will be found to run almost at right angles to those running up the combe, and right across the slopes, always commencing at one straight line and having the curved termination before alluded to. This, I think, shows conclusively that *natural* causes could not result in two sets of opposing terraces occurring under precisely similar geologic conditions. These artificial terraces, too, have in many cases quite altered the natural shape of the valley or combe, turning a Λ-shaped valley into a ∩ one, as at Heddington, near Devizes. Again, the walls of these terraces may often be found, when cut into, to be faced with stones; flints in some areas, and sarsens in others, and these walls have, from this reason, been resorted to for the sake of the facing material.

This facing seems to me to have been a gradual process, and is another proof of the artificial origin of the terraces, which go as far back as the Common Field System, as Mr. Seebohm has so well shown in his book on the "English Village Community." The holdings in these fields were divided into strips all of the same length, forty rods long and four rods wide when they were acre strips, and two rods wide when they were half-acre strips. Now a boundary, of course, was necessary to separate strip from strip, and this boundary on the flat land consisted of a strip of turf, or a "balk," or a "mere," as it was termed.

Now in the case of the hill slopes it would not be so easy to keep a well-defined boundary, owing to the wash of the soil when cultivation began. No doubt to begin with, the strips were marked by cutting into the side of the hill, and we see that they all started from one straight line. To keep the boundary, stones seem to have been used, and fresh marked each year no doubt, as the line became soiled up. In process of time these lines upon lines of stones would result in a bank faced with stones, as we now find, and in flat ledges or terraces on the hillside.

These terraces, moreover, are often found associated with pit-dwellings, earthworks, and old trackways; and I have generally found near them many pot-boilers or flints, which when heated were used for cooking purposes. Hence, a very much stronger case can be made out for the artificial than for the natural origin of those terraces, as shown by Scrope, Seebohm, and others.

F. J. BENNETT.

SALISBURY, *July* 8, 1897.

SCOLOCYSTIS, ECHINOCYSTIS, AND *LYSOCYSTIS: DISCOCYSTIS, ECHINODISCUS,* AND AGELACRINIDÆ.

Sir,—In his valuable paper "On *Echinocystis* and *Palæodiscus*" (Quart. Journ. Geol. Soc., liii, 123–36, pl. vii, February, 1897), Dr. J. W. Gregory has a footnote (p. 133) that may, if not emended, give others as much trouble as it has given me. "To save further confusion" Dr. Gregory proposes the name *Scolocystis* for an obscure cystid to which the preoccupied name *Echinocystis* was given by Hall. We are not told what Hall, what species, or in what publication, although a mysterious thing called "Hall's date" is discussed. My friend Dr. Gregory kindly allows me to say that the reference is to *Echinocystites nodosus*, James Hall, "Account of some new or little-known species of fossils from . . . . the Niagara group," 20th Rep. N.Y. State Cab. Nat. Hist., p. 316, 1867, also published in advance as part of 18th Rep., December, 1864, and January, 1865, as well as on p. 360 of Revised Edition, 1870.

Having this information, it is easy to see that the acute Mr. S. A. Miller, in his most useful work, "North American Geology and Palæontology" (1889), to which it is the duty of every writer on American fossils to refer, has anticipated Dr. Gregory, and has there proposed the name *Lysocystites* for the genus of *E. nodosus.*

There is another generic name proposed by Dr. Gregory on p. 131 of his paper, viz. *Discocystis*: this, too, requires some comment. Dr. Gregory argues that *Palæodiscus* and *Echinocystis* are true echinoids, having no connection with the Agelacrinidæ. "There is, however," he says, "one genus which, if correctly described by Worthen and Miller, may be a Carboniferous representative of either *Palæodiscus* or *Echinocystis* [and therefore an echinoid]. According to the description of its authors, this remarkable form has an irregular, sac-like body; above the mouth there is a series of plates which may represent jaws [i.e. echinoid jaws]. The name *Echinodiscus* was given to this fossil by Worthen and Miller, but this term having been preoccupied by Agassiz for an echinid, for which it is still in use, the name of the cystid may be changed to *Discocystis.*"

If Dr. Gregory considers *Echinodiscus optatus* (for that is the species to which he is referring) to be an echinoid, perhaps he will explain why he calls it a cystid and *Discocystis.* That it is a cystid and no echinoid at all, is my firm belief; and had Dr. Gregory been better acquainted with the writings of Mr. S. A. Miller, we should probably have had neither the above enigmatic paragraph nor the name *Discocystis.* At all events no one has any business to fling names about in this reckless way without considering all the facts and possibilities of the case. Three species have been referred to this genus, and should all have been reckoned with by my onomatopœic friend. They are: *E. optatus*, Worthen and Miller (1883), the type-species; *Agelacrinus kaskaskiensis*, Hall ("Geol. Iowa," i (2), 696, 1858), referred to *Echinodiscus* by S. A. Miller ("N. Amer. Geol."); and *E. Sampsoni*, S. A. Miller (17th Rep. Geol. Surv. Indiana, p. 76, 1891). Comparison of these shows plainly that they belong to the Agelacrinidæ. The "mouth," which Dr. Gregory innocently quotes, is the anus, which in 1883 and even later was thought to be the mouth by many American writers. The supposed jaws are presumably the anal pyramid, which Dr. Gregory suggests came to be part of the apical system, i.e. at the aboral pole.

The species, in short, though perhaps not referable to the Carboniferous genus, *Lepidodiscus*, do not depart from the plan of the Agelacrinidæ, and anyone who wishes to maintain them in a separate genus should be asked to show the differences between them and *Agelacrinus*, *Haplocystis*, and one or two other of their allies.

Dr. Gregory appears to accept Haeckel's view that the ambulacra of the Agelacrinidæ bore pinnules. This may have been the case with one or two of the genera placed by Haeckel in *his* Agelacystidæ; but it can scarcely have been the case with any of the genera mentioned by Dr. Gregory.

It seems as well to indicate these minor lapses, which none will regard as detracting from the interest or value of my friend's long-looked-for paper.

British Museum (Nat. Hist.),
London, S.W.

F. A. Bather.

OBITUARY.

THE REV. ROBERT HUNTER, M.A., LL.D., F.G.S.

Born 1823. Died February 25, 1897.

Robert Hunter was born at Newburgh in 1823, and was the son of Mr. John Mackenzie Hunter, a Scotsman from Portpatrick, in Wigtownshire, his mother being (*née* Agnes Strickland) an Englishwoman from Ulverston, in Lancashire. In 1826 his father, with his family, removed to Aberdeen. There Robert Hunter, after attending the leading academy, entered the Grammar School, then under the celebrated rector, Dr. Melvin. Here he took the first prize in the third, fourth, and fifth classes of the school, and afterwards, when still only fourteen, he came out at the head of seventy-nine competitors in the open examination for University bursaries. He thus obtained the first, and entered Marischal College in the University of Aberdeen. There, a few months later, he was first in Latin and first in Greek, and in the third year first also in Mathematics. Among secular studies, however, Natural Science had supreme attractions for him. This subject was conducted by Dr. John Shier, and in his second year Robert Hunter gained the first prize, the second being awarded to Hugh Mitchell, afterwards Minister of the Free Church, Ferryden, who proved in later years a most excellent geologist and palæontologist. [The Rev. Hugh Mitchell, M.A., LL.D., passed away on November 10, 1894, and his obituary, written by Dr. Robert Hunter, his friend and former classmate (now, alas! also lost to us) appeared in the Geol. Mag. for 1894, p. 575.] Robert Hunter and Hugh Mitchell, with an ardour prophetic of future eminence, roamed the country for many miles around the granite city making Natural History collections. But, as the result of prosecuting researches in spite of wind and weather, Hunter was laid up for three months with a serious illness. The day of competition for the Mathematical scholarship to be held for two years arrived, finding Hunter still confined to his bed. But the same indomitable pluck which carried him through numberless other severe trials in later life, stood him in good stead. He arose and entered the lists "pale and emaciated," but came out bracketed first with another student, with whom Hunter divided the spoil. At the end of the arts curriculum, these two young men were singled out to receive from the University the degree of Master of Arts "with honourable distinction." Hunter afterwards, in the Divinity Hall, obtained the Lord Rector's prize for Hebrew.

On quitting Aberdeen he went out as a tutor to the Bermudas, and determined to occupy his spare time in studying the Natural History of those islands. Having been introduced to Professor Owen by one of the Scotch Professors, he received particular directions for collecting corals, and preservative fluid in which to place the living coral-polypes for subsequent examination. In this task Hunter was most successful, bringing back, in 1845, excellently preserved examples of the "Brain-coral," *Meandrina cerebriformis*, with the animal, which Owen declared to be the finest specimens which (at that time) had reached this country. He was also placed in communication with Sir William Reid, the Governor of Bermuda, and through him was introduced to Sir William Hooker, of Kew, who evinced a warm interest in Hunter's botanical researches. At this time he might have readily obtained an engagement as a naturalist; but he was so strongly impressed by the conviction that his vocation was in the service of the Free Church of Scotland, that he once more resumed his theological studies.

Subsequently Mr. Hunter offered himself for the Foreign Mission Service, was accepted, licensed, and ordained, and in 1847 he was sent to be the colleague of the Rev. Stephen Hislop, at Nagpore (Nágpur), Central India. Hislop, like himself, was a born naturalist. For upwards of eight years Hislop and Hunter worked together in the heart of the old Mahratta kingdom, which was not then, as now, under British, but under native rule.

Whilst earnest in the missionary cause, in their walks and mission tours their keen scientific proclivities impelled them to take note of the geology, the fossils and the minerals, of the country. Thus we find them sending home papers to be read at the Geological Society of London—"On the Geology of the Neighbourhood of Nágpur, Central India" (see Quart. Journ. Geol. Soc. 1854, x, pp. 470–473, and 1855, vol. xi, pp. 345–383, pl. x); "On the connection of the Umret Coal Beds with the Plant-beds of Nágpur, and of both with those of Burdwan" (op. cit. 1855, xi, pp. 555–561). After 1855, the geological work in India wholly devolved upon the Rev. S. Hislop, although sympathized in most warmly by the Rev. Dr. Hunter here at home. "Tertiary Deposits associated with Trap-Rock in the East Indies, and Fossil-shells from those deposits" (op. cit. 1860, xvi, pp. 154–182, and pls. v–x); "On the Age of the fossiliferous thin-bedded Sandstone and Coal of Nágpur" (op. cit. 1861, xvii, pp. 346–354); "Supplementary Note on the Plant-bearing Sandstone of Central India" (op. cit. 1862, xviii, p. 36);

"Fossil Teeth and Bones of Reptiles from Central India" (op. cit. 1864, xx, p. 117 and pp. 280–282).

The fossil plants collected by them from Nágpur were described by Sir Charles J. F. Bunbury, in the Quart. Journ. Geol. Soc. 1861, xvii, pp. 325–346, plates viii–xii. A Labyrinthodont reptile (named *Brachyops laticeps*) was described by Professor Owen from Nágpur (Quart. Journ. Geol. Soc. 1855, vol. xi, pp. 37–39, pl. ii; 1859, xv, p. 647; and 1861, xvii, p. 353). Professor T. Rupert Jones described the Fossil Cypridæ from Nágpur (Quart. Journ. Geol. Soc. 1860, vol. xvi, pp. 186, 187, 189, pl. x).

"Hislopite," a new mineral, was designated after his friend by the Rev. Prof. Haughton (op. cit. 1860, vol. xvi, p. 160), and "Hunterite" by the same author, after Dr. Robert Hunter.

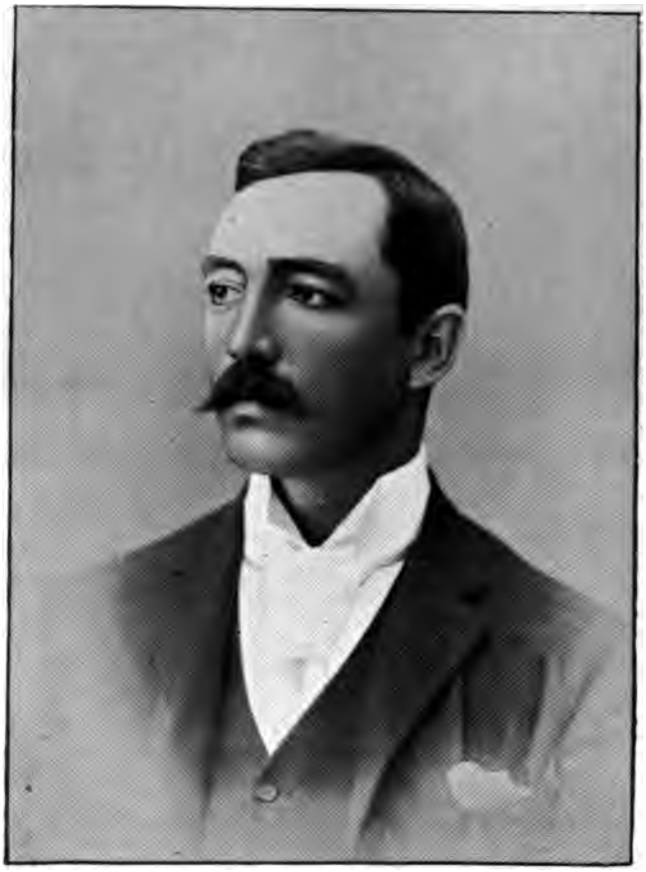
The effects of a tropical climate, however, began to tell upon Mr. Hunter's constitution, and in 1855 his health completely broke down, and he was ordered to start at once for Europe. Thus the personal association of these two ardent Scottish geologists and naturalists in India terminated, but their warm friendship continued until severed by the sad death of the Rev. S. Hislop, by drowning, on September 4, 1863, about twenty miles from Nágpur, in attempting to cross a river in flood after dark, when only in his 46th year.

Dr. Hunter continued to carry on the work of the Free Church Missions, preaching on behalf of the cause for India at home. He suffered the loss of a brother, also engaged in the missionary cause, with his wife and child, who were killed during the Indian Mutiny.

Taking up literature, the Rev. R. Hunter wrote for the British and Foreign Evangelical Review, and brought out in 1863 his "History of India." For two years he held the office of resident tutor in the Theological College of the Presbyterian Church in London, but resigned in 1866, in order to enjoy greater freedom in preaching and in the pursuit of his literary work. His contributions to the magazines were at one time most varied and prolific, but his "colossal work," as Sir Richard Owen called it, was the bringing out for Cassell & Co. the "Encyclopædic Dictionary," upon which he spent seventeen years of his life; the first seven years working entirely alone, but afterwards with assistance. This was followed by a manual of the Bible. He did splendid work with schools and a church at the Victoria Docks, the latter built for him by Mr. James Duncan. He was elected an F.G.S. in 1868, and the Senatus of Aberdeen University, in 1883, conferred upon him the degree of LL.D.

Those who (like the writer) had the good fortune to know the Rev. Dr. Hunter personally, must have been struck by his extreme modesty and simplicity of character, and his amiable and unselfish nature. Yet beneath this unassuming and retiring exterior there lay vast stores of learning which were at anyone's command who might ask his help.

He has bequeathed by his will a sum to be devoted to the working out and publishing descriptions and figures of the fossil plant-remains collected by him, and by his friend the Rev. S. Hislop, in Nágpur, [illegible]tral India.—(Partly from *The Presbyterian*, Sept. 15, 1893, and [illegible] 4, 1897.—H. W.)



Yours faithfully
Harry P. Woodward

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IV.

No. IX.—SEPTEMBER, 1897.

ORIGINAL ARTICLES.

I.—A Western Australian Geologist:

Harry Page Woodward, J.P., F.G.S., Assoc. M. Inst. C.E., F.R.G.S ; Honorary Consulting Geologist and Mining Engineer to the Colony of Western Australia.

(WITH A PORTRAIT, PLATE XVIII.)

EVERYTHING relating to the progress of geology in our Colonies is, or ought to be, of interest to geologists at home; and those who have helped forward this movement are also deserving of ecognition and commendation here. The subject of the present notice has left his hammer-marks on the rocks of Western Australia, and has covered many thousand miles on horseback, on oot, by rail and steamboat, from north to south and from east to west of this great region, containing an estimated area of 976,000 quare miles, being about nine times that of the United Kingdom, and covering about one-third of the whole Australian Continent.

Harry Page Woodward was born at Norwich, May 16, 1858, and is the son of Dr. Henry Woodward, F.R.S., V.P.G.S., Keeper of he Geological Department in the British Museum (Natural History) ; and grandson of Mr. Samuel Woodward, of Norwich, the well-known geologist and antiquary; so that he represents the third of a line of geologists, and belongs to a family in which uncles and cousins are also noted men of science. After being educated at University College School, London, he studied geology with Professor Judd in he Royal College of Science, South Kensington, and field-work with his cousin, Mr. Horace B. Woodward, F.R.S., of the Geological Survey of England and Wales. In 1883 he was appointed, upon the recommendation of Sir A. Geikie and Professor J. W. Judd, C.B., Assistant Government Geologist to the Colony of South Australia. Here, under that able geologist Mr. Henry Y. Lyell Brown, F.G.S., he Government Geologist for South Australia, he served for three and a quarter years, covering a large mileage area, and making several reports on the goldfields and other regions of that Colony. He also served for some time as geologist on the Boundary Commission between New South Wales and South Ausralia, and saw a great extent of the interior of the country. During his residence in South Australia, H. P. Woodward visited Melbourne and inspected the principal mines at Ballaarat and other places in the colony of Victoria. In 1886 he returned to London and spent a year in the Metallurgical Laboratory of the Royal College of Science On December 2, 1887, having been appointed by the Secretary of State for the Colonies to the post of Government Geologist for Western Australia, he sailed for King George's Sound, arriving in Perth in January, 1888. Here, under the direction of Sir Malcolm Fraser, the Surveyor-General and Commissioner of Crown Lands, and Sir John Forrest, the present Premier, he was called upon to visit, and make reports upon, the vast line of proclaimed goldfields, from Kimberley, Pilbarra, and Ashburton in the north, to the Murchison, Yilgarn, Dundas, and Coolgardie Goldfields in the south. He studied and reported upon the Irwin River and the Collie Coalfields; the Greenbushes Tinfield, near the Blackwood River; and was constantly in request to advise about questions of water-supply in all parts of the colony. In his Annual Report for 1890 he published his first general geological description of the Colony. This was in such demand and so quickly out of print that it became necessary to supply in some way the much needed information. This took the form, in 1894, of a Mining Handbook to the Colony of Western Australia, which has had a phenomenal circulation, and the same year saw the publication of a Sketch-Map of Western Australia (geologically coloured so far as Mr. Woodward's explorations had then extended).

About 1882, Mr. E. T. Hardman (of the Irish Geological Survey), who was employed to report on the Kimberley district, discovered gold there, which proved to be rich and to extend over a large area, but situated as it is, in such a distant part, it did very little good to the settled portion of the Colony.

In 1887, the year of Mr. H. P. Woodward's appointment, Mr. Anstey discovered gold at Yilgarn, about 200 miles east of Perth; and although the earlier finds proved to be of little value, they led to the subsequent discovery of a permanent and payable field a few miles further south. The next discovery, in 1889, east of Roeburn, led to the opening up, in the north-west, of the Ashburton Goldfield, where on the river of that name some rich deposits were also met with, and a large quantity of alluvial gold was sent away in a short time. The Murchison Goldfield followed in 1891, where many rich reefs and a large quantity of alluvial gold were discovered.

The most sensational discovery was that made in 1892, by a man named Bayley, about 100 miles due east of Southern Cross. Here a very large quantity of gold was obtained, and one reef which has been the wonder of the Colonies. In 1893 another (the Dundas Goldfield), still more to the south, was proclaimed, and Mr. H. P. Woodward was sent down there as the first Warden.

The records of the subsequent years are all covered by the Coolgardie Goldfield, which still nearly fills the entire picture of Western Australian mining affairs. From this brief account it will easily be seen that Western Australia has become purely a great gold-mining Colony, and, so long as gold pays, the other interests (save as accessories to this one leading industry) fade into the background.

When in January, 1888, Mr. H. P. Woodward landed in Albany, Western Australia was a Crown Colony; but on October 22, 1890, the new Constitution was proclaimed, and the Colony is now governed by a Parliament composed of two Houses, described as a Legislative Council and a Legislative Assembly, both of which are elected by the people, so that the Government, as well as the prospects of the Colony, have alike undergone a great change in the past ten years.

In 1895 Mr. H. P. Woodward, after serving the Colony through this very arduous period of its career, was induced to resign his position of Government Geologist and enter the service of that old-established firm of Messrs. Bewick, Moreing, and Co., of London and Coolgardie. Mr. Woodward most successfully managed their Coolgardie branch for a year and three months; he then decided in the present year to commence business for himself as a Mining Engineer and Consulting Geologist in Perth and Coolgardie.

It is gratifying to state that although the Ministry did not offer any special inducement to Mr. H. P. Woodward to remain in their employ, they yet recognized his past valuable services by conferring upon him the title of Honorary Consulting Geologist and Mining Engineer to the Colony of Western Australia.

In 1883 Mr. H. P. Woodward was made a Justice of the Peace for the Colony. He was elected a Fellow of the Geological Society in 1884, and is also a Fellow of the Royal Geographical Society. He is an Assoc. Memb. Inst. C.E., a member of the Institute of Mining and Metallurgy; a member of the North of England Institute of Mining and Mechanical Engineers, and President of the local branch of that Society. His name is not unfamiliar as a contributor to the pages of the GEOLOGICAL MAGAZINE.

On December 31, 1890, Mr. H. P. Woodward married Ellen Maude, the second daughter of the Hon. J. F. T. Hassell, of Albany, by whom he has three sons.

Mr. Woodward some years ago, with two others, started a vineyard of some 120 acres at Cooringa, about 50 miles from Perth, which is one of the most admirably cultivated and successful undertakings in the Colony. It is now managed by a Company, and the wines are likely in a few years to be honourably recognized in European as they have already been in Australian competitions.

The Editor of the *British Australasian*, writing of Mr. Harry Page Woodward, under date July 1, 1897, p. 1,180, says:—

" When, the year before last, Mr. Harry Page Woodward resigned the position of Government Geologist of the Colony of Western Australia, I expressed my condolence with the Government on the loss they were sustaining, and congratulated Messrs. Bewick, Moreing, and Co. on the acquisition they were making in securing the services of a gentleman of such high attainments, such extensive local experience, and such sound, trustworthy character. I now learn that Mr. Woodward has severed his connection with the firm of Bewick, Moreing, and Co., and started 'on his own' as a Mining Engineer, having his headquarters at Perth. Biography

has nothing to do with business, but people like to be posted in the antecedents of those with whom they are dealing, and for the information of those on this side of the world who may have occasion to require an honest, skilled report on any mining property in Western Australia I append a few particulars of Mr. Woodward's career, which is naturally not so well known in England as in Australia, where his professional life has been spent. [See ante, p. 385.]

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"Besides his official publications, he has contributed many valuable papers to the learned societies, and has published an extremely useful Mining Handbook to the Colony of Western Australia.

"Mr. Woodward was the first to predict the discovery of artesian water upon the plains to the westward of the Darling Range in Western Australia, where the numerous bores put down are yielding an abundant supply of fresh water. Also, unfortunately, his prediction has up to date proved equally true that no artesian water would be struck upon the goldfields. From their first discovery, Mr. Woodward had the very highest opinion of the value and permanence of the goldfields, advocating strongly the construction of a railway into the interior long before the Government had sufficient confidence in their success to incur the cost of making it. He always in his official capacity as Government Geologist did his best to protect the British investor from the numerous spurious and worthless undertakings put forward by the unscrupulous to ensnare the public, and for which he received the usual thanks.

"He acted for some months as Warden of the Dundas Goldfields, and is thoroughly acquainted with all the goldfields and other mineral areas of the Colony.

"It will be seen from the above that Mr. Woodward has established a right to the title of 'expert,' which seldom appertains to the numerous self-confident gentlemen who without any credentials have assumed the diploma, greatly to their own gain and the loss of the British investor."

II.—The Erosive Power of Rivers and Glaciers.

By R. M. Deeley, F.G.S.

ALTHOUGH we are probably well acquainted with all the chief agents of change, the long-continued action of which has shaped the surface of the earth into mountain and valley, and laid down and metamorphosed the deposits forming those portions of its surface which natural or artificial sections or excavations have enabled us to examine, there still remains considerable difference of opinion, not only as to the particular agent or agents which have formed many deposits, but also as to the rapidity with which changes have been brought about by them in the past. However, since the days when plutonists and pluvialists contended for the supremacy of fire and water respectively, geologists have come to recognize the fact that the rocky crust of the earth has been caused to reach its present form and condition by the operation of quite a number of agents of change acting both separately and conjointly. But it must not be assumed that any particular agent everywhere and under all conditions produces similar effects, for its work may really be both of a formative and destructive nature. Thus, the sea washes down the cliffs, and then assorts and spreads the débris over the sea-floor. Rivers also, although they erode deep and broad valleys, spread over the lowlands wide deposits of gravel, sand, and brick-earth.

That there is still much to be settled concerning the erosive action of both rivers and glaciers is clear, for papers treating of these subjects frequently appear, the authors of which contend, with some show of reason, that, from a theoretical point of view, the work attributed to these agents is, sometimes, apparently inconsistent with our views concerning their methods of working. More especially is this the case in all matters relating to ice and its work. But ice-work and river-work are so intimately bound up the one with the other, that it is necessary to deal somewhat in outline with the latter if the former is to be made clear.

Rivers, like other elements of change, are not wholly erosive agents, for we have seen that their valley bottoms, even at points distant from the sea, are often covered by widespread deposits of gravel, sand, and brick-earth, having thicknesses closely related to the depths and volumes of water passing down the rivers by which they were formed.

In valleys, the falls of which are rapid, the streams cut vertically into the rocks below, forming gorges or ravines having V-shaped sections. In the lower grounds, where the rivers are less rapid, vertical erosion proceeds slowly, the streams impinging against their banks and more rapidly eroding their valleys horizontally than vertically. The lowland valleys therefore have the typical ⊔ section. Along the bottom the river winds, changing its position constantly, and here and there cutting crescent-shaped masses out of the hillsides. But the stream rebounds from side to side at every turn, and constantly tends to accentuate the sinuousness of its course by cutting into its banks. The river, however, does not become broader, for the material eroded from the outside of a curve, or brought down by tributary streams, is piled upon the inside of the curve, and the channel, as it were, moves bodily sideways. This filling up of the shallows on the inside of every curve with gravel, sand, and brick-earth, results from the fact that the centrifugal force of the water at the surface as it sweeps round a curve is greater than that of the slower current at the river bottom. The flow is consequently diagonally across the bottom, and carries stones, etc., with it, much as the leaves in a saucer of tea are piled up in a central heap when the liquid is stirred. In fact, the mass of water rotates as well as moves forward, sometimes in one direction and sometimes in another, according as it is deflected by the curves of the river. At such bends the stream is deep and narrow, but in the straight reaches this rotary motion does not occur, and the river shallows and broadens. Gravel and coarse sand are not thrown up, as a rule, on the inside of a curve to a height much exceeding the ordinary water-level of the river. On the top of the coarser material fine sand and mud then collect, mainly at flood times, between the grass reeds and rushes where they root in the shallows, and in this manner the level is raised to flood-line. It thus comes about that the river deposits a bed of alluvium, the lower gravelly portion of which has a thickness equal to that of the river in ordinary flood, whilst the upper surface of the sand and brick-earth on the top indicate the extreme flood rise. But in course of time the sinuosity of the curves becomes so pronounced that the bends approach each other; the river then cuts through the narrow peninsula and deserts a portion of its course, which slowly silts up, and often leads to the preservation in the clay and mud of mammalian and other remains.

The active nature of this looping tendency may be seen by examining any good map of a district where two counties are separated by a river, for in such cases we shall find patches of a county stranded on the opposite side of the stream. As long as the river moves bodily in a lateral direction it, of course, carries the boundary-line with it, but, when a loop is cut off, an island is first formed, and then by the silting up of the old channel through which the boundary passes a piece of land which stood on the right bank is transferred to the left bank, or *vice versâ.* A river by wandering about in this way from side to side may excavate a broad valley and spread out a sheet of alluvium having a width of several miles and a thickness of twenty feet or more. When vertical as well as horizontal erosion is going on some of this gravel is often left on the valley-sides, and forms wide terraces, the highest at any point above the river being the oldest.

It is important to note that the river, although it is spreading sheets of gravel and sand over its valley floor, is also deepening and widening it, i.e., we have erosion and deposition going on hand in hand under the action of one and the same agent. The gravel is everywhere of nearly the same thickness as it is traced away from the stream, is covered by brick-earth except where it has been denuded from the edges of the higher terraces, and rests upon older rocks, which may be of any age, including Pleistocene Boulder-clays, etc.

As a valley becomes deep and approaches the sea-level the fall becomes small and vertical erosion ceases. The river then attacks the sides of its valley only, rapidly carries away the gravel terraces, and we eventually have produced an approximately flat alluvial plain bounded by long steep escarpments. It must be remembered that terraces, which are removed in this final stage, by no means necessarily indicate that the river has paused at any particular level, for gravel must have been left at all heights below the highest terrace, though only occasional patches may have escaped subsequent enudation. Neither does a flat plain always indicate river-work of his kind, for many of the old river valleys of Norfolk and Suffolk ave been depressed at a comparatively recent date beneath the sea, nd have slowly been filled up with gravel, sand, and mud brought own by the rivers and brooks, or removed by the waves from the ea cliffs and driven inland. The well-known Broads are merely solated patches of what were extensive estuaries. Here, however, we are concerned with the effects resulting from the combined ction of sea and river.

The changes which occur from season to season in the volume f water passing down stream depend not only upon variations in he rainfall, but likewise upon the porosity of the rocks over which he water flows. Indeed, it often happens that so large a percentage f the rain sinks immediately into the ground, and rises again as prings in the beds of the principal rivers, that the volume of water assing seawards is very considerable even during dry weather. owever, although the river channels may be somewhat rapidly nd continuously eroded, the general land-surface occupied by nsoluble rocks does not suffer very rapidly. But the case is ifferent if the rock should be a soluble one, for the springs are hen exceedingly hard and great quantities of material pass to the ea in an invisible form. The ease with which rainwater finds its ay into the ground, and after passing for long distances beneath t again comes to the surface, has, we shall find, an important bearing pon one aspect of glacier erosion. Vegetation also has an important ffect upon the rate of erosion, for it prevents the loose soil from eing readily washed down the slopes, and in estuaries accelerates he rate at which silting up takes place. In this manner climatic ffects tell, for in high latitudes the land, which is often bare of egetation during a considerable portion, if not the whole, of the ear, is softened and loosened by frost, and the soil-cap slides odily down the hill slopes, producing one variety of what we know s "trail" and "underplight." Erosion effected in this way can carcely be called river erosion: by this we mean the scouring ction of the current, largely due to the grinding action of the tones and grit it contains, on the sides and bottom of the channel. Even when the rocks are soft the erosive power of the stream is argely due to the pebbles carried along the bottom.

Now, if from any cause the supply of débris brought down from he hills by lateral streams should be greater than the river can arry away, then instead of erosion taking place and gravel terraces eing formed the valley may become choked to a great depth with rough gravel, mud, etc. In cases where the supply of débris rought down in this way is not sufficient to actually choke the main stream, as is the case in the Indus Valley, the lateral streams, where they debouch on the plains, spread out immense fans of gravel n the alluvial deposits. However, in course of time the river cuts nto them and hurries the material towards the sea.

The levelling action of rivers is well shown by some of the valleys in Colorado. There earth-movements of such a character have taken place that mountain ranges have been slowly thrown up right in the track of the rivers. But their erosive power has been sufficiently great to enable them to maintain their courses unaffected, cutting cañons six or more thousand feet deep, and preventing anything like the formation of lake basins in their main valleys. Indeed, the whole tendency of river action is to fill up depressions and bring large areas of country to an almost dead level. But it is notorious that the valleys in many mountainous districts present characteristics which cannot be traced to river action. To explain such phenomena as are there met with we must turn to water working under different conditions, i.e. in the solid form.

Ice as well as running water, there is no doubt, has had a considerable share in the excavation of many valleys. In them we often have smoothed, scratched, and polished rock-surfaces, and heaps and ridges of morainic matter on the slopes or forming low hills stretching across their bottoms. Some of these consist of angular débris carried down on glaciers as medial and lateral moraines, whilst others are crescent-shaped ridges of rough gravel. In the lower grounds especially these give place to wide sheets of Boulder-clay which have often choked up the old valleys throughout the whole or portions of their courses, and in some cases have dammed up the rivers and formed immense lakes.

One interesting feature in particular of glacier-eroded valleys may be mentioned. It is the peculiar step-like way in which they descend from the mountains. First we have the consolidated snow on the mountain-sides descending into wide basins, along which it moves with only a very small fall. It then plunges down a more or less steep slope into a second long basin, and so on. Such a descent is that down which the Rhône Glacier descends into the gravel-covered plain beyond. But a ride down the valley will reveal several such rapid descents separated by nearly horizontal U-shaped stretches. Here and there, however, the cross-section simulates the ⊔ section of a river-eroded valley, but there is reason to believe that the level plain is merely a deep accumulation of the material ejected from the cave at the glacier end. Down the steep slopes separating such level stretches, the road plunges in a series of zigzags, the river passing from the higher level to the lower level through deep V-shaped gorges which it has cut.

Indeed, just as a river tends to make its course through its alluvial plain more and more sinuous by attacking the outside of each curve, so does a glacier exert its main erosive power at or near the bottom of a slope where its direction changes, and where the thrust and pressure upon its bed are at a maximum. In this way is produced a valley which descends to the lowlands in a series of giant steps, the upper ends of which are often occupied by lakes.

The extent to which valleys have been excavated, and their outlines altered by glacier action, is, indeed, very striking, V-shaped valleys having been converted into U-shaped ones, and their bottoms so deeply cut into that they are frequently occupied by a succession of lakes, many of which rest in true rock basins. Attention has recently been called by Dr. Wallace to a number of the peculiarities of these valleys and lakes. Indeed, upon the question of the origin of lake basins the discussion of the erosive power of ice has largely turned.

The opponents of Ramsay's theory of glacier erosion base their opposition almost wholly upon theoretical considerations of a more or less unsatisfactory kind, holding that ice can only polish and grind, and could not have shaped the valleys and excavated the lake basins in the time we can reasonably expect the glaciers to have been active. Even here, however, their notions of chronology may be woefully at fault. But there are those also who hold that the rate of erosion at and beyond the terminal portion of a glacier is greater than beneath it, and that, consequently, a lake basin can never be formed by erosive action beneath the ice. But this is quite contrary to the teaching of the phenomena to be seen in such positions.

We have pointed out that the handiwork of glaciers in the form of masses of Boulder-clay, gravel, and sand, is so extensive and stretches from the mountains into the lowlands to such great distances, that it is difficult, reasonably, to resist the conclusion that the erosive power of glaciers is very great indeed. Seeing this, some popular writers have attempted to revive the ancient theory of vast floods and great earth convulsions.

Dr. Wallace shows that small lateral valleys seldom, if ever, enter the main valleys at such heights as to cause a lake to branch into them. When such branching occurs it is due to the confluence of two important valleys or to the flow of a glacier over a neighbouring "col." But these features are by no means confined to valleys occupied by lakes. The valley of Chamouni may be well instanced. Here, on one side, the valleys in which the Glacier des Bossons, the Mer de Glace, and the Glacier d'Argentiere rest, terminate abruptly on the valley-side at a great height above the Arne, and the ice from them is precipitated in great cascades down the slope. On the opposite side the upland valleys, although not occupied by glaciers, present the same features, a steep climb bringing one suddenly into an upland basin-shaped valley. The main valley really appears to have been cut like a huge trench through everything.

In everything, however, that relates to ice and its work contradictory phenomena present themselves. In the first place it is a brittle substance, and yet when fragments of it are pressed together, at or near the melting-point, they readily weld together. And, again, O. Mugge[1] has proved that a crystal of ice is not at all viscous, i.e., it will not deform even slowly under the strains produced by small stresses, and is only plastic like moist clay in a direction at right angles to the optic axis; yet glacier ice, which consists of countless angular particles of the sizes of peas, beans, or walnuts, all frozen firmly together, presents in mass the properties of a viscous substance like pitch, owing to a molecular action which takes place between the glacier grains,[1] and the glacier moves slowly down its rocky bed in a manner much resembling that of a river. Again, a glacier will often pass over loose deposits of bedded sand and gravel without disturbing them in any way, whilst in other instances it will move rock-masses, measuring hundreds of yards in length for miles, and actually tear up large boulders from its rocky floor. The apparently contradictory effects produced by other agents should warn us not to assume too readily that because ice can polish it cannot excavate, or because it can erode it cannot deposit, or that because in one case it passes over loose sand without disturbing it it cannot break up and remove hard rocks. A consideration of the properties of ice will, however, serve to make such contradictions less startling.

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[1] "Ueber die Plasticität der Eiskrystalle": Jahrbuch für Mineralogie, 1895, p. 211.

Unlike the water of a river, which is stationary when actually in contact with fixed objects, we have abundant proof that the ice of a glacier when in contact with its floor is not *always* frozen to it; for the glacier carries stones and sand along, and polishes and scratches many of the rocks it passes over. Some writers seem to take it for granted that glaciers are nowhere actually frozen to their beds, and, basing their conclusions upon this assumption, arrive at results which are inconsistent with the facts. But we have no evidence which proves that glaciers really are *always* separated from the rocks upon which they rest by a liquid film. On the contrary, our knowledge of the properties of ice would rather seem to support the opposite view, i.e., that they are frequently firmly frozen to their beds over large areas.

When a piece of lake ice is placed between the opposing faces of a press, and considerable pressure is applied, a portion of it becomes liquid, and the mass assumes a stratified appearance, owing to the formation of liquid layers. To produce these liquid films heat is required, and as this has to come from the ice the whole mass falls slightly in temperature. Indeed, experiment has proved that the freezing-point of water is lowered by pressure. Now beneath a thick glacier, owing to the pressure resulting from its weight, the ice must be at a lower temperature by a degree or so than at its upper surface, and this no matter if the pressure is applied in a vertical direction only. We are here dealing with the same substance in two physical conditions, but the only practical difference that exists between them, for our purpose, is that the ice is enormously more viscous than the water. In the form of water its viscosity is exceedingly small, and for all practical purposes it may be considered as unable to transmit stress if applied in one direction only. As ice, its viscosity being enormously great, it can transmit stresses for yards or even miles in a direct line. We may, consequently, have ice under great pressure in contact with water scarcely subjected to any stress whatever. Such conditions, however, are not stable ones, and must give rise to continuous thawing and refreezing.

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[1] Geol. Mag., Dec. IV, Vol. II, 1895, p. 152.

Between ice in this condition and other rocks, when the water can escape through the porous ground, and is therefore not subjected to any great hydrostatic pressure, it has a freezing-point above that of the ice, and the conditions are favourable for the adherence of the glacier to its bed. The exact nature of the freezing process may be seen by considering the case of a wire loop passed over a piece of ice and weighted at its ends. In such a case the ice under pressure melts, the water moves round the wire and again freezes on its top. In this way the wound is healed as fast as the wire cuts its way down, and the sling finally passes right through the mass without separating it into two portions. When resting upon a porous rock, such as sandstone or gritstone, each particle of quartz pressed into the glacier causes it to melt, and a portion of the low-temperature water, as it escapes, freezes again in the sandstone. Indeed, rough porous surfaces must imbed themselves into the glacier and resist sliding, even should they not actually freeze to the glacier. The tendency of ice is really rather to adhere to the bottom, and drag along with it, and break up, the rocks upon which it rests. In all glaciated districts, as a matter of fact, porous rock-surfaces beneath Boulder-clays, or over which ice has passed, are contorted, torn, and trailed, and but seldom striated or polished.

Soil-cap motion has been largely pressed into service to explain many of the features which have really resulted from the drag of a glacier along its bottom. However, a critical examination of the phenomena presented by some forms of "trail" and "underplight" reveals peculiarities which soil-cap motion, resulting from gravity, could not have caused, the direction of flow indicated by it frequently being uphill, or sufficiently powerful to bend and displace rocky beds. This tearing and breaking-up action of glaciers also comes into play when they pass over hard but jointed and bedded rocks.

There are few geologists who have visited glaciated districts who have not been struck by the great difference in the appearance of valleys viewed from the two aspects, up and down. Looking down, all the surfaces and outlines are seen to be rounded, whereas looking up, rough, rocky, and irregular surfaces everywhere meet the eye. According to the teaching of one school, these rough surfaces were formed before the advent of the glaciers, and represent portions of the old Pre-Glacial weathered surfaces; the subsequent work of ice having merely served to round and smooth one side of them. Such a view affirms that the erosion affected by the glaciers must have been very small. But the angular and unweathered appearance of these craggy surfaces, and the presence of large quantities of angular unweathered rock in the great moraines and sheets of boulder-clay, clearly negative this view, and prove that glacier erosion has really been extremely active.

Now when a glacier moves down a valley it presses heavily against each boss or hummock of rock it touches. Here melting takes place and the temperature is low, but if the rock be dense and impervious the water cannot readily escape. However, on the top and lee side of the boss the pressure is relieved, the water escapes through grooves, joints, etc., and the ice freezes to the rocks with which it is in contact, tearing up, if the joints allow it to do so, large masses which are then carried forwards. The rate at which erosion is effected in this manner must depend largely upon the direction of the dip and the jointing. In many valleys, however, the rocks are so massive and impervious that they have succeeded in largely resisting the erosive power of the ice. But even in the absence of large hummocks in the path of the glacier the rocky floor must always be so irregular that the local variations of pressure must give rise to local freezing. In this way the whole forward stress of large masses of ice is concentrated *locally*, and the hard floor is dealt with in *detail*. When we remember that a glacier may at one time be moving over a bed of sand and slowly drag along with it an inch or two of its surface without in any way disturbing the lower portions, or glide easily over a dense tough clay, and in another may meet some obstruction, be compelled to move or more or less change its course, and displace the obstruction to a greater or lesser extent, it is clear that we must expect to meet with all sorts of conflicting evidence concerning the real nature of the work glaciers accomplish. Indeed, in the study of glaciated districts we find every kind of action: in one place rocks are polished and scratched, in another deeply grooved, or they may be broken and bent over at a sharp angle at their upper surfaces. Soft clays are bent, crumpled, and contorted, striated and polished stones kneaded eight or more feet deep in marls and clays, and masses of older rock drawn up and buried in the beds above. The Cromer cliffs exhibit splendid examples of this action.

Indeed, just as we find that the deposits formed by rivers vary with the rate of flow, the nature of the rocks they erode, and many other circumstances, and that they are sometimes acting as denuding and at other times as depositing agents, so it is reasonable to argue that the effects wrought by glaciers must also depend upon their rate of flow, their thickness, the nature and surface contour of the rocks over which they move, whether they actually enter the sea or lakes, or terminate on land, etc., etc.

Towards its extremity, where it enters the warm air of the lowlands, the water on the surface of a glacier finds its way through crevasses, or melts its way down the glacier-side to the bottom of the ice-filled valley, and then flows through a wide tunnel until it emerges into the open. The tunnel-sides are of course constantly closing in, and the stream by melting its retaining-walls is continually moving its position. In this way boulders find their way into the stream, are well rounded, and finally ejected along with sand and fine mud.

Outside the tunnel at the end of the glacier the volume of the stream is seldom sufficient to carry away all the coarse débris, which, therefore, collects at the end of the glacier as an enormous fan, sloping at a small angle, it may be, for miles down the valley, and choking it to depths of hundreds of feet in some instances. Temporary advances of the ice may crush this rough gravel up into great ridges of water-worn rock, such as those, remnants of which are to be seen above Cardiff, Swansea, etc.

During the cold periods which caused the glaciers of Switzerland to stretch out beyond the hills, erode many of the lake basins, and give the valleys their characteristic outlines, the coarse gravel thrown out from the ice caves choked the valleys of the Rhine, Rhône, and other rivers, to great depths. However, during warmer periods, the modern valleys have been excavated through them, and glacial gravel now forms extensive terraces overlooking the newer deposits.

III.—The Geologically Recent Origin of the Surface Contour of Scandinavia and Finland, and its Lessons.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

(*Concluded from the August Number*, p. 361.)

LET us now turn to the angular gravel itself, the so-called Krosstensgrus of the Swedes, which is formed in the main from crystalline rocks, from granite, and gneiss, hälleflinta or petrosilex, crystalline limestones, mica-schists, quartzite diorites, diabases, porphyries, etc. This angular gravel Erdmann not only pronounces to be moraine material, but the only moraine material in the country. How it is possible to correlate this angular drift with any kind of moraine material, or to explain the angular gravel of Sweden by the intervention of ice, I cannot understand, any more than I can understand the application of the same cause to the angular gravels of Southern England and Northern France. That a jointed rock when soaked with water in summer will split into fragments along its joints or cracks when that water is frozen in winter, is true enough, but these variations of temperature are quite impossible under a glacier, and if they were possible they would not cause the splitting of flints, of granite and gneiss and porphyry, into splinters. Nowhere do we find work of this kind being performed in the homeland of glaciers at the present time, nor can I conceive its possibility.

It seems to me as plain as possible that these angular gravels of Sweden, which occur at all levels among the surface beds, have nothing to do in any way with ice. The angular gravel is clearly connected with the angular erratics; they form a continuous series marked by the same features, and they seem to me explainable by one cause only, that which I have already invoked to account for the broken and angular rubble in the Chalky Clay of England, namely, a violent breaking up of the solid matrix of the rocky beds *in sitû* by some subterranean force. Have we any evidence of spasmodic changes of the surface involving the breakage of the strata *in sitû* in the area we are discussing?

One of the most curious facts in recent Glacial literature has been the substitution of the phrase Baltic ice-sheet for that of Norwegian ice-sheet, which was formerly used. This change of phrase is amply justified. Whatever it was that distributed the Scandinavian boulders or made the inland striæ on the rocks, it was not from the Dovrefeld and highlands of Norway that the force came, but from the much lower land a hundred miles to the east of the watershed. This is admitted by every Scandinavian geologist. Professor J. Geikie himself, in the last edition of his "Great Ice Age," says: "Dr. Törnebohm and Professor Högbom have shown that the glacier-carried erratics of Jemtland demonstrate that the ice passed from east to west—that is, right against the slope of the land; and, according to Keilhau, similar blocks, which could only have come from Sweden, are now found in Trondhjems-fiord; while Pettersen has recorded similar facts in connection with the glacial phenomena of Northern Norway." Mr. Geikie goes on to say: "The most remarkable circumstance in connection with some of these blocks consists in the fact that they occur at a considerably greater height than the rock from which they have been derived. Thus, at Åreskutan, Törnebohm found blocks at a height of 4,500 feet, which could not possibly have come from any place higher than 1,800 feet" (op. cit., p. 424).

This is surely an extraordinary concurrence of facts, so extraordinary that it ought to have received a great deal more serious attention than it has done, for it involves quite a bundle of puzzles and paradoxes, especially when combined with the theory that prevails among the glacialists. How are we to account by any process for the ice-sheet, which they profess to say accumulated, not on the highlands of Norway, but in the lowlands of Sweden, Lapland, and Finland, and thence drove its burden, not only for hundreds of miles horizontally, but for thousands of feet uphill? First, Sweden, Lapland, and Finland are peculiarly dry areas. The only wet winds of Europe are the south and south-west winds: these beat upon the mountains of Norway, which drain them of their moisture, and they pass over into Finland and Sweden as dry winds. How, then, could it ever have been possible, unless the contour of the country has been entirely revolutionized, not only to accumulate an ice-sheet on the land in question, but to make the ice-sheet culminate there? The position involves a meteorological absurdity.

Suppose, however, we could obtain such an ice-sheet: in order that it should drive stones uphill for thousands of feet, or travel for hundreds of miles to the south, it must necessarily have not only been of great depth, but also had a great surface slope, for we can no longer have recourse to a polar ice-sheet to give impetus to the movement. A succession of observers, from Böhtlingk downwards, have destroyed Agassiz's postulate of a polar ice-sheet by showing that the stones were distributed northwards from this area as well as in other directions. If so, how could an ice-sheet, blanketing the comparatively low land of Sweden and Finland, get hold of any boulders at all, or of any stones, for the whole country would have been covered fathoms deep in ice, and, as we know from the case of

Greenland, there are no transported boulders and no moraines where there are no rocks projecting above the surface of the ice. These are some only of the difficulties involved in the position as generally argued. They are paramount difficulties.

The burden of my argument, however, is not so much at this stage to press home the impossibility of this ice-sheet, as to urge that any explanation that is forthcoming seems inadequate to illuminate the position unless we also grant, not merely a slow and secular rise of the land, but that the whole contour and internal relations of the different parts of Scandinavia have been greatly altered since so-called Glacial times by differential movements. I had written this sentence, when I was pleased to find my inference corroborated by the very high authority of Lyell. After describing the dislocations of the chalky beds of Denmark, to which he assigns a very late date, he goes on to say:—"Hence we may be permitted to suspect that in some other regions, where we have no such means at our command for testing the exact date of certain movements, the time of their occurrence may be far more modern than we usually suppose. In this way some apparent anomalies in the position of erratic blocks, seen occasionally at great heights above the parent rocks from which they have been detached, might be explained, as well as the irregular direction of certain glacial furrows like those described by Professor Keilhau and Mr. Hörbye on the mountains of the Dovrefeld in lat. 62 N., where the striation and friction are said to be independent of the present shape and slope of the mountain" ("Ant. of Man," p. 394). Let us prosecute this view somewhat.

That the upward movement of the Scandinavian peninsula, which is conceded by everyone, was not equable and quite continuous, is also generally admitted. It is proved among other things by the terraces existing on the coast of Norway and Lapland, and which mark intermittent periods of repose or of slower movement; but this intermittence will not explain the facts. The facts, in truth, require that we should postulate that at one time there was a much greater and more rapid movement. The barnacles seen by Brongniart and Lyell were found at one height only. If the rise had been more or less intermittent even, we should have had several of these barnacle patches at different heights, or a continuous series of them. It does not seem possible to account for the isolation of the Swedish and other lakes and their separation with their marine animals from the sea, except by a rapid movement. The whole country intervening between the great lakes and the sea is eloquent of violent breakages and ruptures, notably those about Trollhättan. This *a priori* probability is amply supported by all the facts we can collect, and I would venture to press them on the attention of those whose eyes have been closed to all evidence of cataclysmic action by their allegiance to another god.

If the position be just for which we have pressed in a previous paper, that Eastern England and the bed of the North Sea as far east as the Danish islands was bent into a series of enormous north-and-south folds at the very time when the Drift was being distributed, we can hardly doubt that the same movement extended to the

Scandinavian peninsula. This is confirmed by the general contour of the country, which is apparently moulded on the principle of a succession of great hollows and elevations, arranged in roughly parallel lines; one deep hollow being the trough running along the western coast of Norway, another trough being the Gulf of Bothnia and the Baltic, while the intervening peninsula forms a gigantic down; and it may well be that this contour was first given to the country comparatively recently, and in fact contemporaneously with the foldings of the bed of the North Sea and the dislocations of the Chalk in Norfolk and in Denmark, and that when the so-called Drift was deposited not only was the Dovrefeld not the watershed of the peninsula, but the whole country was comparatively flat and plain. If the contortions of the strata were like those further west, and like those forming the Ural Mountains, which we long ago argued belonged to the same era of upheaval, it is also probable that as in those cases they were the results, not of slow movements, but of cataclysmic ones leading to the breakage and disintegration of the crystalline rocks on a great scale. It is only in this way we can account in fact for the prodigious mass of angular or subangular boulders and rock fragments of Scandinavian and Finnish primitive rocks, which not only strew those countries but are also found over Central Russia and Germany. Their number and size seem absolutely inconsistent with their having been the result of ordinary diurnal denudation by frost and rain acting upon exposed peaks, and the country is much too low to admit of this deduction being justifiably imported as a hypothesis from the entirely different conditions in the Alps. It points very forcibly to some tremendous strain which smashed and broke up the beds just as we have seen the Chalk beds of Eastern England and of Denmark were disintegrated and broken. Apart from this, have we any direct evidence of these more or less rapid and gigantic movements and dislocations in Scandinavia? In the high Norwegian mountains the evidence is, of course, not easy to find, since we have no chronometer by which to test when the rupture and dislocation of the crystalline masses of the Dovrefeld took place. We do not know *directly* when the great mass was upheaved, necessarily leading to the creation of the transverse fissures we call fjords, and it would in fact appear from the paucity of Norwegian boulders in the northern Drift, compared with Swedish and Finnish ones, that the Norwegian beds largely escaped the breakage. When we get further east, however, into Sweden we do have such evidence.

In this behalf I would quote some interesting observations of Sefström and Murchison, in Dalecarlia, which have been overlooked and forgotten. The former tells us that M. H. Wegelin had told him that the mountains bounding Norway, Herjedalen and Dalecarlia, did not consist of any fixed continuous strata, but of a mass of large and small pieces of rock which have sharp edges, and therefore have never been rolled, that they were all rent asunder or shattered to pieces on the spot; that none of the blocks are furrowed; and he elsewhere refers to similar phenomena in the porphyry rocks westward of Lake Siljan ("An Investigation," etc., pp. 112–3). In regard to the same phenomena, Murchison says that in travelling between Upsala and Sala, one is suddenly immersed in a chaos of angular blocks, some of them of gigantic size. Seeing that they were all composed of granitic gneiss, and no proof that these millions of angular blocks were deposited on åsar, and from their linear arrangement, he concluded that they must be simply fragments *in sitû*, the subjacent rock being hidden by their great profusion. He noticed that whenever an elevation presented itself, sometimes not exceeding 15 or 20 feet high, it was covered with angular blocks of all sizes accumulated on a substratum of clay. "On entering Dalecarlia we passed," he says, "a true granitic plateau covered in parts with angular blocks, the mass of which, like those above alluded to, forcibly reminded us, by its superficial aspect, of the broken volcanic *cheires* of Auvergne . . . . they were fragments *in sitû*, the subjacent rock from which they had been broken off appearing here and there. On passing the low hills south of Fahlun the angular blocks and the underlying parent gneiss were clearly exposed. Without such an explanation, the sea of wild and irregular fragments dotted over the plain immediately south of the copper-mines of Fahlun would indeed seem marvellous. . . . . In passing from the Siljan to the Wenjan lake we passed through a country of low wooded porphyry peaks, the parent rock of which is also almost entirely obscured by vast quantities of local angular blocks, and on approaching Johannisholm the observer is suddenly struck with great quantities of sandstone débris, and on traversing the Wenjan lake all other detritus disappears, and the whole mass consists of angular blocks, occasionally of enormous size, composed of hard red, purplish, greenish, or whitish sandstone, which constitutes the cover to a vast expanse of horizontal sandstone, which further to the north is detected beneath this chaos . . . . this *Felsenmeer* or *cheires* consists of enormous angular blocks of purely laminated sandstone and occupies a tract many miles in length, no part of which is more than 100 or 200 feet above the lake. . . . . In numerous spots, indeed, the blocks of sandstone, though completely disjointed and widely separated, conform on the whole to a horizontal arrangement, and it was only at very rare intervals that we could detect the subjacent horizontal rock from which they had been dislocated." Whatever cause, says Murchison, is assigned for the production of this chaos *in sitû*, there can be no sort of doubt that the same agent has operated over several degrees of latitude in Sweden, effecting exactly similar results on innumerable low ridges of hard rock, whether composed of granite, gneiss, of quartz rock, or porphyry, or of finely laminated sandstone. Murchison proceeds to entirely dispute that such a condition of things could possibly result from any kind of subaerial denudation, and appeals to some powerful mechanical agency by which the chaotic arrangement of enormous blocks apparently *in sitû* has been produced, and further appeals to successive and sudden upheavals of the Northern chain of Scandinavia, aided by a corresponding depression in the south, suggesting that the angular blocks resulted from a number of sudden shocks or jars, which, without throwing the beds up into distinct ridges as in many parts of the world, simply shattered them into numerous fragments by general convulsive earthquakes which affected broad horizontal areas.

Evidence of a similar kind, but not on the same scale, was collected by Sefström from other parts of Sweden. Thus, he says, south of Brōms, on the boundary between the districts of Calmar and Blekinge, the granite is all broken and the pieces lie with their sides irregularly elevated or sunken, much in the same manner as pieces of ice formed at high-water, and the water having sunk the ice rests on an uneven bottom. From this, he says, no other conclusion can be drawn than that the displacement has been caused by some subterranean cause. Further west, near the church of Lösen, are several great fragments of a large slab which has been detached from the main rock below. "It is also," says Sefström, "soon discovered that this slab has been, by a shock from the north, removed a little further south, and that it has been partly crushed to pieces by the shock." Again, Sefström speaks of the fact that in Sweden, on opening new mines the solid rock is seldom found until we reach a depth of from one to two fathoms; until we reach this the mountain is, as it were, shivered, and is full of fractures and fissures filled with a shiny powder of the same or some other rock, and not unfrequently ending in a large open chasm. This is clearly seen about a mile from Fahlun. He also quotes the opinion of Berzelius, that in West Gothland some violent cause has broken and carried away the Silurian rocks, except where protected by a covering of trap. Sefström and Murchison have shown further how the various and sporadic angular blocks which are found in Sweden can be traced right up to these ruinous masses of rock actually *in situ*, and there can be no doubt that whatever force it was which carried them that force derived them from these centres of distribution. These facts point, it seems to me, to only one reasonable conclusion, namely, that the angular blocks of Scandinavian origin and also the angular gravel, like the angular and subangular débris in the Chalky Clay of England, are the direct result of the breakage of the surface beds at a time when the surface contour of the country was violently altered and remoulded, and they show that the phenomena which we have traced in Norfolk and in the Danish islands are also forthcoming in the Scandinavian peninsula. The phenomena are clearly the result of the immense strain exercised upon beds *in situ* by sudden upheavals and the operation of more or less violent forces, and they in fact testify to the most important elevation of the land in Sweden having been violent and rapid.

The double conclusion here pressed for, namely, that the larger part of Scandinavia and Finland was recently under the sea, and that the surface of the country has been to a large extent violently and spasmodically smashed and broken, are important conclusions when taken separately, and when connected together involve still more important ones. The question which immediately suggests itself, considering that these great masses of broken and splintered rock *in sitû* are situated in an area where the land must have been submerged by the great North Sea, whose existence everybody allows, is how is it that they are not weathered and rounded and worn, but remain perfectly sharp and untouched? If they had been submerged for any length of time, they must necessarily have shared the fate of the rounded boulders and the rounded gravel of Scandinavia.

On the other hand, if this part of the country has ever been smothered in ice since they were in existence, how comes it that this fact of their being unweathered should be so marked, and that these stones should all be sharply angular and not ice-worn, striated, and smoothed? Ice could not pass for any length of time over these enormous heaps of angular stones and leave them in this condition. The only inference possible seems to be, that if there ever was an ice-sheet here it must have been before the existence of these broken masses, and that neither ice nor water have lain long upon them, or been able to play with them, or to knock them about, or to rub over them. I cannot see how this conclusion is to be avoided.

While, however, it is true that we can in these stones see no traces whatever of ice-action or of the presence of ice, nor yet of their having been submerged for a length of time under a glacial sea, there is evidence that a rapid current of water has passed over them. On this subject I will quote a pregnant sentence of my master, Murchison.

He says:—"Notwithstanding the almost perfect angularity of these broken masses (which are just like the fragments that fall from natural joints in a quarry), it is curious to observe that occasionally (though rarely) a small rounded boulder of porphyry may be detected between their interstices, and that here and there a considerable quantity of sandstone and smaller detritus is mixed with loose sand, and is seen lying around the base and lower edges of the blocks. This fact seems to prove that by whatever cause the blocks were dislocated, water has since passed over and between them, though not with such power in this tract as to abrade them, and merely transporting a very few foreign pebbles, has only had sufficient energy to clear away much of the intermediate loose sand and smaller broken materials, converting them into the fragmentary shingle which we see in the traînées to the south of this sandstone range." (Q.J.G.S., ii, p. 376.)

The whole puzzle now becomes clear on condition that we discard that bastard form of philosophy which persists in attributing results to inadequate causes because of the tyranny of some *a priori* doctrine. The only conclusion which seems available is, that the force which reformed the outline of Scandinavia and converted the sea-bed which once occupied so large a portion of Northern Europe into dry land, acted violently and spasmodically as similar forces on a smaller scale have recently done in Japan.

One result of this was the breaking up of some of the surface crystalline beds of Central Sweden, and probably also of Finland, into a mass of angular débris; but this is only one lesson. The other lesson, which seems as plain as Belshazzar's message, is, that this violent and spasmodic upheaval of the bed of the great North Sea caused it to shed its waters in violent and overwhelming force in all directions, and thus brought about the phenomena which have been such a puzzle and a paradox to the orthodox followers of Hutton and of Lyell, who, like all disciples, have utterly exaggerated the teaching of their masters. This is not my conclusion only. I am only the devoted scholar of much greater men, and among them of the greatest geologist we ever produced in this country, which means the greatest geologist of all time—Murchison—who stands out among most of our contemporary lights like the Eddystone lighthouse would if transplanted among the gas-lamps of Piccadilly. He had the courage to speak out his real convictions, and I can only say Amen.

IV.—NOTES ON SOME OF THE LAKES OF CAERNARVONSHIRE.

By W. A. BREND, B.A., B.Sc., F.G.S.

SINCE the publication of Mr. Marr's numerous papers on the tarns and lakes of the English Lake District, considerable attention has been paid to the manner of formation of lake-basins in the glaciated regions of Britain; a few notes therefore on some of the lakes of North Wales may not be without interest.

At the head of the Nant Ffrancon Valley, between the range of the Glyders and Carnedd Dafydd, are situated about half a dozen small tarns. The largest of these, Llyn Ogwen, exhibits several features of interest. Rock *in situ* can be traced all but continuously round the lake. The exit is over rock; on the north side Craig Dhu and Craig-yr-Yrfa slope steeply up to over 3,000 feet; on the south are Tryfan and the Glyders. An alluvial flat extends back from the head of the lake for about half a mile; this is completely rock-bound except for an interval about 40 yards wide just north of Pont Bodesi. The ground here is about 30 feet above the surface of the lake, and is flat and marshy, so that it is impossible to determine whether solid rock or drift material lies beneath the surface. The watershed between the Dena and the Llugwy is about a quarter of a mile further east, and consists of a mass of drift. The extreme shallowness of the lake is remarkable, and rather tends to increase the probability of a drift dam at the point described above. Soundings showed a depth of from 5 to 6 feet at the narrow end, shelving gradually to about 8 feet in the widest part, and then sloping upwards, rather more rapidly, towards the eastern boundary of the lake.

To the south-west of Ogwen, deep set amid frowning precipices, lies Llyn Ldwal, one of the wildest tarns of Wales. Ramsay describes it as being partly dammed up by a terminal moraine, but he also adds: "the water is, I incline to think, partly retained because it lies in a rock-basin ground out by the old glacier." He admits, however, that he is ignorant of the depths of the tarn. Soundings of Llyn Ldwal do not support this view; the greatest depth obtained was 30 feet, but as the mass of drift at the exit extends down the valley for a considerably greater vertical distance than this, before rock can be traced across, it seems probable that drift damming alone has operated in the formation of the lake.

Llyn Bochlwyd lies to the east of Llyn Ldwal, at a height of 1,800 feet above sea-level. Ramsay considers it to be "slightly dammed up by moraine material." There is no opportunity of sounding this tarn, but if it is a true rock-basin it must be of considerable depth, as the drift at the exit is very thick. Moreover, it is difficult to account for the irregular outline of the tarn on the theory of glacial erosion.

Two other small tarns in the neighbourhood were examined—Llyn-y-Crôm, lying above the gorge of Twll-Du, and Llyn Clŷd to the west of Ldwal. Round neither of these could rock *in sitû* be continuously traced. Ffynnon-y-Lloer, beneath the summit of Carnedd Dafydd, is not described by Ramsay, but drift material is marked round the exit on his map. Rock *in sitû* can, however, be traced within this, but at a point about 40 yards to the north of the end of the lake there is a thick mass of moraine matter, and it is here probably that a dam exists, as the lake is apparently shallow.

To the south and east of the ridge terminating in Moel Siabod lie two tarns—Llyniau-duwaunedd and Llyn-y-foed. The first of these lies in a deep valley, across the end of which runs a ridge of rock, broken, however, in two or three places by marshy and peat-covered intervals, beneath which drift material might lie. Llyn-y-foed at first sight looks very much like a rock-basin, rock *in sitû* being exposed nearly the whole way round; at the south-west angle of the lake, however, a deep depression, about 30 yards wide, appears to be filled with drift material.

Several features of interest are presented by the group of long, narrow, and roughly parallel lakes, which lie to the north of the Capel Curig and Bettws-y-Coed road, and drain into the valley of the Conway. Llyn Geirionydd, the most easterly, is situated at a height of 616 feet above sea-level. The western side of the lake is formed by the rugged mass of Mynydd Deulyn rising abruptly from the margin to over 1,300 feet. Rock *in sitû* can be traced continuously from the left bank of the outflowing stream to just behind the cottage Tal-y-llyn at the head of the lake. Here there is an alluvial flat about 200 yards wide, and then rock is again exposed in the stream flowing from the reservoir. By going a considerable distance in a south-westerly direction solid rock can be traced round the tract of alluvium. The eastern shore of the lake is formed by the steep grass-covered slopes of Pen-y-Drum, varying from 900 to 1,000 feet in height. To the east of the exit stream rock *in situ* can be detected along the footpath; but between this and the stream is an area of which, though it does not look like a drift-filled depression, it is not possible to speak with certainty. It is flat and marshy, and though drift is not visible neither is rock. The narrowest point is about 10 feet below the level of the lake; a drift dam here, then, must be 40 feet thick, as the maximum depth of the lake is 50 feet. It may be pointed out that the shape of the western margin of Llyn Geirionydd renders any explanation of its formation by glacial erosion difficult to accept.

About three-quarters of a mile to the west on the other side of Mynydd Deulyn is Llyn Crafnant, situated 602 feet above sea-level. The stream, which drains the lake, flows out through a gorge about 100 yards long: on the left bank a cliff rises nearly vertically for about 40 feet, and then slopes back; on the right bank is a path about 3 yards wide, and then a steep rocky declivity. Rock *in situ* occurs below the path at intervals along the margin of the stream. The actual bed of the stream is filled with large boulders, and it is impossible to trace rock across it. The narrowest place is a point about 10 feet below the level of the surface of the lake; here the rock-walls of the stream are 17 yards apart; in other places the distance between them varies from 20 to 30 yards. If the loose material seen in the bed of the stream really dams up the lake, it must descend to a very considerable depth, as the writer obtained several soundings over 70 feet, and Mr. Kingsley, who sounded the lake some years ago for the Ordnance Survey, found 90 feet in one place. As the fall through the gorge is considerable, and the stream pretty strong, it does not seem probable that the loose material can be of any great thickness.

Considerable attention has been paid to the description of the exit of Llyn Crafnant, as there seems to be no other place where the lake is likely to have been dammed. Bare and rugged mountains rise up continuously all round the lake, in one place only below 1,000 feet high. This is a narrow depression through which the path from Llyn Geirionydd runs; the highest point is about 360 feet above the surface of the lake. Here the interval across which rock cannot be traced is about 25 yards wide; 200 yards south-east of this the width is reduced to less than 20 yards. If this depression represents a drift-filled valley damming the lake, it is at its highest part from 60 to 80 feet wide for about 200 yards and at least 430 feet deep. The existence of such a rift as this seems highly improbable.

The lake is shallow at the narrow end, and shelves down gradually to about 30 feet just beyond the first tributary stream; from this point it shallows to about 15 feet opposite the next tributary. From here it deepens rapidly to about 70 feet near the centre of the lake. A depth of between 50 and 70 feet is maintained for some distance, and then it rapidly shallows up to the alluvial flat.

A large lake, Llyn Cawlyd, about a mile to the north-west of

Crafnant, deserves a few words. It is girt in by mountains on either side, and to the south-west; the stream which drains the lake flows in a north-easterly direction, through a gently sloping valley filled with drift and alluvium. The narrowest part of the valley is some distance above Pont Brwynog, about 100 feet below the level of the lake. Here there are masses of rock *in situ* about 130 yards apart. The shape of the lake-basin is interesting; the deepest part is near the head of the lake, where it reaches 230 feet; for some distance the depth varies from 180 to 210 feet, and then the lake shallows gradually up to the exit. If the lake is formed by the blocking of this valley, the drift must be 130 feet thick at the narrow area mentioned above, which necessitates a rate of fall of two in three of the sides of the valley buried beneath the drift. This is very much greater than the rate of fall on either side above the drift.

It is possible that in the case of Llyn Crafnant and Llyn Geirionydd, one almost certainly a rock-basin, the other very possibly so, earth-movements may have been wholly or partially responsible for their formation. The same agency may conceivably have operated in the case of Llyn Cawlyd.

Llyn Eigiau lies to the east of Carnedd Llewelyn. It is quite shallow, judging by the rushes which grow a long way into it. The eastern shore is low and covered with peat, which probably conceals moraine material.

The writer is indebted to Mr. J. E. Marr, F.R.S., for many kind suggestions and criticisms; and to Mr. Kingsley for information as to the depths of Llyns Geirionydd and Cawlyd.

V.—On a Jurassic Lamellibranch and some other associated Fossils from the Sarawak River Limestones of Borneo; with a Sketch of the Mesozoic Fauna of that Island.

By R. Bullen Newton, F.G.S.

The Mesozoic Fauna of Borneo.

CERTAIN deposits in the neighbourhood of the Seberuang River, a tributary of the Kapuas in Western Borneo, were described by R. Everwijn[1] in 1854 as containing numerous so-called "Nummulites." Similar organisms were obtained at a later date from the same district by Dr. F. Schneider, which were examined by Dr. K. Von Fritsch[2] and proved to belong to the genus *Patellina*. Two new forms were described and figured under the names of *P. scutum* and *P. trochus*, whilst the occurrence of *Patellina* itself suggested to Von Fritsch the probability of the beds in question being of Cretaceous age. A further study of this material induced

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[1] "Voorloopig onderzoek naar Kolem in de landschappen Salimbouw Djonkong en Boenoet in de Residentie Westerafdeeling van Borneo": Nat. Tijdsch. Nederlandsch. Indië, 1854, vol. vii, p. 387.

[2] "Patellinem von der Westseite von Borneo": Palæontographica, 1878, suppl. 3, pp. 144, 146, pl. xix.

Professor K. Martin[1] to abolish Von Fritsch's supposed new species in favour of the more typical form of the genus *Patellina* (*Orbulites*) *concava*, Lamarck, a fact of considerable importance, since it enabled him to fix upon the Cenomanian stage of the Cretaceous series as the definite horizon for these particular beds of Western Borneo. In 1883 some molluscan and other remains were obtained from near Sajor on the river Seberuang through Mr. R. D. M. Verbeek,[2] and examined by Dr. H. B. Geinitz[3] and Dr. G. Böttger, who both regarded them as of Lower Senonian age. They were determined as follows[4]:—

Natica cf. *Gentii*, Sby. (*canaliculata*, Mant.).
N. lamellosa, Röm.
Phasianella, sp.
Avellana, sp.
Panopea cf. *gurgitis*, Brong.
P. cf. *mandibula*, Sby.
Pholadomya (*Goniomya*) *designata*, Goldf.
Astarte, sp.
Trigonia cf. *limbata*, D'Orb.
Lyonsia cf. *Germari*, Gein.
Vola cf. *quadricostata*, Sby.
Modiola cf. *capitata*, Zittel.
Gervillia cf. *solenoides*, Defr.
Spondylus, sp.
Lima, sp.
Arca, sp.
Ostrea, sp.
Hemiaster Regulusanus, D'Orb.
H. sublacunosus, Gein.
H plebejus, Novák.
Patellina, sp.

An interesting Cretaceous fauna was next discovered at numerous localities in the Martapura district of the south-eastern part of the island, which has been fully monographed by Professor K. Martin.[5] The remains of some Rudistiform shells were first described under *Sphærulites* and *Radiolites*, but without specific names on account of their imperfect preservation, though supposed to show some relationship to Stoliczka's species from Southern India, *Radiolites mutabilis* and *Sphærulites Indica*. A second memoir dealt with the remaining groups of these fossils, embracing the Echinoids, Brachiopods, Lamellibranchs, Gasteropods, and Cephalopods. The entire fauna was regarded as of Upper Cretaceous age, and on account of its resemblance to Southern Indian forms Martin recognized it as equivalent to the Arrialoor group of that country. The complete list of these specimens is as follows:—

Cidaridarum, sp. indet.
Terebratula Dutempleana, D'Orb.
T. (*Terebratella* ?) *Borneensis*, sp. nov.
Ostrea (*Exogyra*) *ostracina*, Lam.
O. (*Alectryonia*) *Martapurensis*, sp. nov.
Ostrea (*E.*) *Borneensis*, sp. nov.
Ostrea, sp. indet. (4–5 species).
Pecten, sp. indet.
Vola quinquecostata, Sby.
Modiola Hoozei, sp. nov.

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[1] "Untersuchungen ueber den Bau von *Orbitolina* (*Patellina*, auct.) von Borneo": Sammlungen geol. R.-Mus. Leiden, 1890, No. 20, vol. iv, part 7, pp. 209–231, pls. xxiv, xxv.

[2] "Over het voorkomen van Gesteenten der Krijtformatie in de Residentie Westerafdeeling van Borneo": Versl. Med. K. Ak. Wetenschappen, 1883, vol. xix, p. 39.

[3] "Ueber Kreidepetrefacten von West-Borneo": Zeitsch. deutsch. geol. Ges. 1883, vol. xxxv, p. 204.

[4] The nomenclature given in these lists of fossils is that of the authors themselves, no revision of the same having been attempted by the present writer.

[5] "Ueber das vorkommen einer Rudisten fuehrenden Kreideformation im Suedoestlichen Borneo"; "Die Fauna der Kreideformation von Martapoera": Sammlungen geol. R.-Mus. Leiden, 1889, Nos. 18, 19, vol. iv, parts 4, 5, pp. 117–197, pls. xiii–xxi.

Trigonia limbata, D'Orb.
Cardita (*Venericardia*) *Hoozei*, sp. nov.
Astarte (?) *Martapurensis*, sp. nov.
Crassatella proteus, sp. nov.
C. (?) *Borneensis*, sp. nov.
C. macrodonta (?), Sby.
Ptychomya Indica, sp. nov.
Sphærulites, sp. indet.
Radiolites, sp. indet.
Cardium Djaricanense, sp. nov.
Cyprina (*Venilicardia*) *mordax*, sp. nov.
Roudairia gigantea, sp. nov.
Venus, sp. indet.
Cytherea Assahanensis, sp. nov.
Pholadomya Sundaica, sp. nov.
Natica (*Gyrodes*), sp. indet.
Nerinea Sedetensis, sp. nov.
N. Hoozei, sp. nov.
N. Sundaica, sp. nov.
N. Borneensis, sp. nov.
N. Martapurensis, sp. nov.
N. Horneri, sp. nov.
N. Djaricanensis, sp. nov.
N. (*Itieria*) *Schwaneri*, sp. nov.
Alaria, sp. (?).
Strombus (*Pugnellus*), sp. indet.
S. Martapurensis, sp. nov.
Helix, sp. indet.
Nautilus Trichinopolitensis, Blanf.
Ammonites (*Acanthoceras*), sp. indet.
Scaphites, sp. indet.

During the following year Dr. Martin[1] described some Lamellibranch shells from Sepang and Soengei Mottong, Western Borneo, as *Gervillia Borneensis*, sp. nov.; *Gervillia*, sp. indet.; *Corbula*, sp. indet. They were obtained from the "Alte Schieferformation" (a name given to a series of deposits embracing argillaceous and siliceous schists, sandstones, conglomerates, and in other ways assuming the character of a Palæozoic formation), and judged to be of Mesozoic age, possibly Cretaceous. In 1895 the same author[2] announced the discovery of Jurassic Mollusca by Mr. Wing Easton and Dr. J. Bosscha at various localities in or near the Sambas district of Western Borneo, which in the succeeding year formed the subjects of separate papers by Dr. F. Vogel[3] and Dr. P. G. Krause.[4] Dr. Vogel's list includes the following species, all of which are new, and the author is inclined to refer them to the Weisser Jura horizon of the Oolites:—

Protocardia crassicostata.
P. tenuicostata.
P. multiformis.
Corbula Borneensis.
Exelissa septemcostata.
Amauropsis (?) *Borneensis.*
A. (?) *Sambasana.*
Strombus, sp. (?).
Ficula, sp. (?).

Dr. Krause's contribution is concerned with the description of some Liassic Ammonites and a doubtful form of *Inoceramus*, from an argillaceous shale. The Cephalopods are referred to the genus *Harpoceras*, of the group *H. radians*, Reinecke, the typical species of which is characteristic of an Upper Lias age.

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[1] "Versteinerungen der Sogenannten alten Schieferformation von West-Borneo": Sammlungen geol. R.-Mus. Leiden, 1890, No. 20, vol. iv, part 7, pp. 198–207, pls. xxii, xxiii.

[2] "Die Mesozoischen Schichten von West-Borneo": Sammlungen geol. R.-Mus. Leiden, 1895, No. 21*a*, vol. v, part 2, pp. 29–34.

[3] "Mollusken aus dem Jura von Borneo": Jaarb. Mijnw. Ned. O.-Indië, 1896, vol. xxv, pp. 1–27, pls. ix, x: Sammlungen geol. R.-Mus. Leiden, 1896, Nos. 21*b*, 22, pp. 127–153, pls. ix, x.

[4] "Ueber Lias von Borneo": Jaarb. Mijnw. Ned. O.-Indië, 1896, vol. xxv, pp. 28–42, pl. xi: Sammlungen geol. R.-Mus. Leiden, 1896, Nos. 21*b*, 22, pp. 154–168, pl. xi.

TABULAR LIST OF THE MESOZOIC FAUNA OF BORNEO, INCLUDING THOSE FORMS REFERRED TO IN THE PRESENT PAPER.

Genera and Species.	Lias.	Oolite.	Cretaceous.
Cephalopoda.			
Ammonites (Acanthoceras), sp. indet.	—	—	x
Harpoceras (group H. radians, Reinecke)	x	—	—
Nautilus Trichinopolitensis, Blanf.	—	—	x
Scaphites, sp. indet.	—	—	x
Gasteropoda.			
Alaria, sp. (?)	—	—	x
Avellana, sp.	—	—	x
Amauropsis (?) Borneensis, Vogel	—	x	—
A. (?) Sambasana, Vogel	—	x	—
Exelissa septemcostata, Vogel	—	x	—
Ficula, sp. (?)	—	x	—
Helix, sp. indet.	—	—	x
Natica cf. Gentii, Sby. (canaliculata, Mant.)	—	—	x
N. lamellosa, Röm.	—	—	x
N. (Gyrodes), sp. indet.	—	—	x
Nerinea Borneensis, Martin	—	—	x
N. Djaricanensis, Martin	—	—	x
N. Hoozei, Martin	—	—	x
N. Horneri, Martin	—	—	x
N. Martapurensis, Martin	—	—	x
N. (Itieria) Schwaneri, Martin	—	—	x
N. Sedetensis, Martin	—	—	x
N. Sundaica, Martin	—	—	x
Phasianella	—	—	x
Strombus (Pugnellus), sp. indet.	—	—	x
S. Martapurensis, Martin	—	—	x
S., sp. (?)	—	x	—
Lamellibranchiata.			
Alectryonia amor, D'Orb.	—	x	—
Arca, sp.	—	—	x
Astarte, sp.	—	—	x
A. (?) Martapurensis, Martin	—	—	x
Cardita (Venericardia) Hoozei, Martin	—	—	x
Cardium Djaricanense, Martin	—	—	x
Corbula, sp. indet.	—	—	x
C. Borneensis, Vogel	—	x	—
Crassatella (?) Borneensis, Martin	—	—	x
C. proteus, Martin	—	—	x
C. macrodonta (?), Sby.	—	—	x
Cyprina (Venilicardia) mordax, Martin	—	—	x
Cytherea Assahanensis, Martin	—	—	x
Gervillia cf. solenoides, Defr.	—	—	x
G. Borneensis, Martin	—	—	x
G., sp. indet.	—	—	x
Inoceramus, sp.	x	—	x
Lima, sp.	—	—	x
Lyonsia cf. Germari, Gein.	—	—	x
Modiola cf. capitata, Zittel	—	—	x
M. Hoozei, Martin	—	—	x

Genera and Species.	Lias.	Oolite.	Cretaceous.
, sp.	—	—	x
xogyra) ostracina, Lam.	—	—	x
.) Borneensis, Martin	—	—	x
lectryonia) Martapurensis, Martin	—	—	x
. indet. (4–5 species)	—	—	x
ea cf. gurgitis, Brong.	—	—	x
mandibula, Sby.	—	—	x
, sp. indet.	—	—	x
domya (Goniomya) designata, Goldf.	—	—	x
ndaica, Martin	—	—	x
ardia crassicostata, Vogel	—	x	—
uicostata, Vogel	—	x	—
ltiformis, Vogel	—	x	—
omya Indica, Martin	—	—	x
lites, sp. indet.	—	—	x
iria gigantea, Martin	—	—	x
ulites, sp. indet.	—	—	x
ylus, sp.	—	—	x
ia cf. limbata, D'Orb.	—	—	x
bata, D'Orb.	—	—	x
, sp. indet.	—	—	x
uinquecostata, Sby.	—	—	x
quadricostata, Sby.	—	—	x
Brachiopoda.			
atula Dutempleana, D'Orb.	—	—	x
rebratella ?) Borneensis, Martin	—	—	x
Bryozoa.			
pora (related to H. conifera, Lamx.)	—	x	—
Actinozoa.			
, sp.	—	x	—
Spongiæ.			
lla (?), sp.	—	x	—
Foraminifera.			
na (Orbulites) concava, Lamarck = P. trochus and P. scutum, Fritsch)	—	—	x

REMARKS ON THE SHELL AND ITS LOCALITY.

e recognition of a European Jurassic Lamellibranch in the of Borneo is thought to be worthy of recording as an addition slight knowledge of the Mesozoic fauna of that country. The in question, identified as *Alectryonia amor*, D'Orbigny, consists r fragments, one being a nearly perfect upper valve measuring illimetres from end to end. Each of these specimens is of ish colour, though covered in places with a loose fawn-tinted sandy material, and stands out in relief on a greyish blue-black compact limestone intersected with veins of calcite, and bearing a water-worn surface. An accompanying manuscript label gives the following information:—"Borneo. *Ostrea colubrina*? Goldf., pl. lxxiv, fig. 5. M.P.G."; the latter letters pencilled on the corner implying that the specimens were transferred from the Museum of Practical Geology to the British Museum during the year 1880.

Considering the extent of Borneo, said to thrice exceed the superficial area of Great Britain, it is to be regretted that no more precise locality has been preserved with the specimens, although a comparison with some further limestones from the same island has enabled me to partially supply this information. I refer to material in the Geological Society's Museum (presented by Mr. Jas. Russell in 1861) localized as from "Bousoe" (probably Busau), and to other specimens in the British Museum, presented by Mr. A. H. Everett a few years since, from Bidi, Busau, Jambusau, Sadong, etc., all of which localities are situated in the north-western part known as the Residency of Sarawak,[1] on or near the river of the same name. These limestones possess similar petrographical characters and the same water-worn appearance, though several of them present whitish, decomposed, weathered surfaces, besides having their fossiliferous structures (corals, etc.) more or less elevated above the general level of the matrix; so marked is this resemblance that I have no doubt the molluscan remains were obtained from the Sarawak River District, and most probably from either Bidi or Busau.

I may here insert the following observations on the geology of this part of Borneo, published by Mr. A. H. Everett[2] in 1878:—"This district consists of an ancient blue limestone (Palæozoic?), on which is superimposed unconformably a thick series of sandstones, conglomerates, and clay-shales, constituting the most extensive series of beds in this part of Borneo; and on these last lie strata of clay-shales, alluvial clay, river gravels, etc., of very recent origin. Piercing the limestone and sandstone we find granite and a variety of igneous and trappean rocks—basalt, porphyrite, greenstones, etc., these latter being developed in great abundance in the antimony districts where they are in immediate contact with the limestone. The latter formation, in which the lodes of antimony are seen *in situ*, is locally rich in fossil organic remains, but I am unable to say whether they have been examined by a competent geologist with a view to approximate the age of the rock; the planes of stratification can seldom be made out with any approach to certainty, but where they are evident they show that the originally horizontal beds have been uptilted almost on end and much denuded; and there is abundant proof that a very considerable interval in time elapsed between the close of the limestone formation and the commencement of the succeeding sandstone series."

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[1] See map of this region by W. M. Crocker in the Proc. Roy. Geogr. Soc. 1881, N.S., vol. iii. p. 256.

[2] "Notes on the Distribution of the Useful Minerals in Sarawak": Journal Straits Branch Royal Asiatic Society, 1878, p. 14.

DESCRIPTION OF SHELL.

Alectryonia amor, D'Orbigny. Knorr (Walch): Naturges. Verstein. Merkw. 1768, part 2, pl. D ii, figs. 5–7.

Ostracites crista-hastellatus, Schlotheim: Petrefactenkunde, 1820, p. 243 (name trinomial, and therefore not acceptable).

Ostrea colubrina, Goldfuss: Petrefacta Germaniæ, 1833, vol. ii, p. 8, pl. lxxiv, figs. 5*a*–*e*; *non* Lamarck, 1819.

Ostrea amor, D'Orbigny: Prodrome Paléontologie Stratigraphique, 1849, vol. i, p. 342.

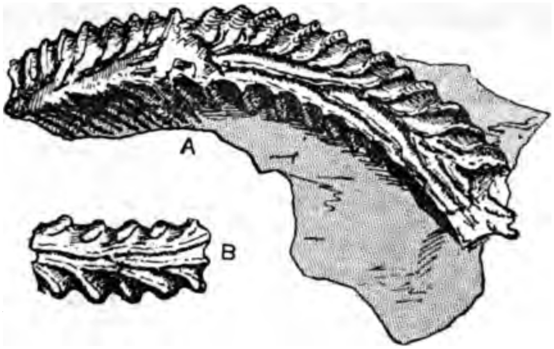
Ostrea hastellata.

Ostrea rastellata, Quenstedt: Der Jura, 1858, p. 750, pl. xci, fig. 27.

Ostrea hastellata, P. de Loriol: Mém. Soc. Pal. Suisse, 1881, vol. viii, p. 97, pl. xiii, figs. 8, 9.

Ostrea (*Alectryonia*) *hastellata*, P. de Loriol: Mém. Soc. Pal. Suisse, 1892, vol. xix, p. 346, pl. xxxvi, fig. 8; ibid. 1894, vol. xxi, p. 72, pl. ix, figs. 1–3.

The first systematic diagnosis of this species was furnished by Goldfuss under the name of *O. colubrina* as follows:—"*Ostrea testa æquivalvi lineari-lanceolata, arcuata, dorso plano lateribus abruptis, plicis dorsi obliteratis luteram subacutis numerosis.*"



Alectryonia amor, D'Orb.

Middle Oolite: Sarawak River District, Borneo.

A. Nearly perfect upper valve (nat. size).

B. Part of lower valve of another specimen showing longitudinal dorsal ribs and grooves (nat. size).

(Originals in the British Museum.)

The shell is elongate, equivalve, narrow, and arcuate; dorsal area flat, with longitudinal ribs and grooves; lateral surfaces almost vertical, and bearing numerous elevated dentiform plications which become somewhat hook-shaped on the dorsal margins; inner side possesses a small aliform expansion, which is covered with more closely-set plications than those on the ordinary sides of the valves.

Affinities.—Among the distinguishing characters of this shell may be mentioned (1) its generally narrow form, (2) its steep vertical sides, and (3) its flattened dorsal area, which is ridged and grooved with elevated longitudinal ribs, the main one bifurcating after a certain distance, then finally merging into smaller ramifications.

There appear to be two Cretaceous species with which this form may be confounded, viz., *A. pectinata*, Schlotheim, sp., and *A. carinata*, Lamarck, sp. The former, however, has more oblique lateral surfaces and is more strongly arched; the dorsal area is not flattened, but bears numerous V-shaped ribs, which extend from the side plications, forming irregular grooves or canals. *A. carinata* possesses deeper and more compressed valves, and a much narrower dorsal region, which although rather similarly ribbed at intervals, yet differs from the present species in having prominent, elevated, and curved points forming the dorso-marginal terminations of the numerous lateral plications.

A form of this genus (*A. Martapurensis*) has already been described from the Cretaceous rocks of Southern Borneo, which differs from the present shell in possessing a keel-like back formed by the meeting of the lateral plications in that area. Excellent figures of *A. amor* have been published, but those given by Goldfuss, Quenstedt, and P. de Loriol are probably the most striking for details. These represent specimens from the Corallian of Nattheim and Switzerland, which are usually better preserved than those from other localities.

Distribution.—According to D'Orbigny the species is restricted to the Middle Oolite, having been found in the Callovian of Pizieux, Villers, and St. Scolasse-sur-Sarthe, in France; Streitberg and Amberg in Germany. It is also recorded from the Corallian of Nattheim in Germany, Switzerland (Bernese Jura), and from similar rocks at Châtel-Censoir, Loix, and Île de Ré in France. Other localities represented by specimens in the British Museum are Viel St. Reine (Corallian) and Vaches Noirs (Oxfordian). We have no record of specimens from the English Oolites.

Observations on the other Limestone Structures.

A microscopical examination of Mr. Everett's limestones in the British Museum has led to the following results:—(1) The identification, with Dr. J. W. Gregory's assistance, of the Bryozoan genus *Heteropora*, exhibiting a colony formed of innumerably small zooecia with faint traces of mesopores, and longitudinally displaying some horizontal tabulæ or diaphragms; in these and other details suggesting a relationship to *H. conifera* of Jurassic seas. (2) In the same block of matrix and close to the specimen of *Heteropora* can be seen the well-defined calices of a coral possessing septa of the hexameral type, and which Dr. Gregory recognizes as *Stylina*, a genus ranging from Trias to Cretaceous times, with a numerous representation in Oolitic rocks, especially those of Corallian age. (3) A sponge has been determined for me by Dr. G. J. Hinde as belonging to the group of the Calcispongiæ and probably to the genus *Corynella*. The specimen appears to me to resemble some Corallian forms of this genus found in the Nattheim beds of Germany.

Quite a number of organisms enter into the constitution of these limestones, but they are more or less obscure and difficult to determine; those referred to on the present occasion are thought to be sufficient for assisting in determining their geological horizon.

CONCLUSION.

So far as I have been able to ascertain, no definite palæontological date has yet been adduced in settlement of the geological age of the Sarawak River limestones, which appear to have been regarded by some authors as Palæozoic. The water-worn varieties especially resemble an ancient formation such as the Devonian coral limestones of Northern Queensland; and the peculiarities of *Heteropora*, which remind one so strongly of the various Monticuliporoid structures found in the older rocks, seem to add considerably to this suggestion. But neither the sponge, nor the coral, nor the mollusc can be mistaken for Palæozoic organisms, and we have in such forms of life evidence of the first character to prove their Mesozoic origin. The example of *Alectryonia amor* allows us to go still further, for this is a good Middle Oolite species, and without the assistance even of the other structures is sufficient to prove that the deposition of the limestones in question must have taken place during that particular period of Jurassic history.

REVIEWS.

I.—SOME GEOLOGICAL EVIDENCE REGARDING THE AGE OF THE EARTH. By J. G. GOODCHILD, H.M. Geol. Survey, F.G.S., etc. 8vo. (Edinburgh: McFarlane & Erskine, 1897.) (Reprinted from Proc. Roy. Phys. Soc. Edinburgh, vol. xiii, pp. 260–303.)

THE age of the Earth has to be calculated from the physical and biological changes of which the rocks bear evidence. The author thinks that their value-in-time has to be taken with reference to changes of the same nature now in progress—that is, with normal uniformity of action in general, but allowing for catastrophism in certain cases. Even in rocks formed previously to those that yield definite organic remains, there is clear evidence, says the author, of winds, tides, and currents having acted as they do now. "Even as far back as the commencement of the Cambrian Period the two great geological factors, *solar energy* and *gravitation*, appear to have operated then very much as now. To a geologist this merely indicates that the close of what has been termed the 'Astronomical History' of the Earth terminated many millions of years prior to the Cambrian Period; and that the Earth must have been in a condition suitable for life through a long period of time when the Archæan rocks were in process of formation."

In calculating the time required for the Physical Changes that have taken place during the Tertiary Period, Mr. Goodchild refers chiefly to the Hebrides for the basis of some of his calculations with regard to changes in the early part of the Tertiary Period. He regards the climax of the Glacial Period to have been about 20,000 years ago; the excavation of the Hebridean and Scotch valleys required 16,000,000 years, if only at the rate of one foot in 2,000 years; and the growth of the Great Old Skye volcano, presumably once 8,000 feet high, and formed at the rate of about one foot in 300 years, took up some 2,400,000 years in the Oligocene Period. In the previous Eocene Period the extensive Nummulitic Limestone had been formed. For all his calculations the author details the statements, statistics, and opinions advanced by many observers. The mode of formation and rate of growth of marine limestones are carefully estimated, and one foot in 25,000 years is taken as a fair rate to allow for the formation of marine limestones other than coral-reefs. The Nummulitic Limestone, if only 3,000 feet thick, required no less than 75,000,000 years for its formation. Thus, a total of 93,420,000 years must have elapsed between the commencement and the close of the Tertiary Period.

In like manner the author calculates the time required for the formation of the Chalk and other Cretaceous strata, explains his views of the relative time-value of the tilting and denuding necessarily associated with unconformities, and proceeds to the consideration of the other Mesozoic formations, and those of the Upper and Lower Palæozoic times. His remarks on the Carboniferous Series are noteworthy. Very different are the estimates that have been made for the time necessary for the production of a foot of coal—thus, by Huxley 500, Boussingault 3,600, Phillips 1,530, Croll 1,600, Humboldt 1,800 years.

These suppositions are for the terrestrial origin of coal; but Mr. Goodchild thinks that some coal-seams may have been sufficiently marine to allow of an average estimate of one foot in 3,000 years. At all events, for the 105 feet of coal-seams near Manchester he would give 315,000 years. This, with 10,500.000 years for the 7,000 feet of Carboniferous sandstones (at one foot in 1,500 years), and 21,000,000 years for 7,000 feet of Carboniferous shales (at one foot in 3,000 years), makes up the sum for the Upper Carboniferous Group.

The author's summary of the time required for the known geological series is as follows:—

	Time in Years.
For the Tertiary Period	93,420,000
For the formation of the Chalk, Upper Greensand, Gault, and Lower Greensand	31,400,000
Pre-Cretaceous Unconformity in Britain	13,200,000
Time required for the deposition of the Jurassic-Wealden Series	59,400,000
Time represented by the Tyrolian and Panormian (together comprising our *Trias* and *Permian*) rocks	87,500,000
Unconformity at the base of the Lower New Red in Britain	45,000,000
Duration of the Upper Carboniferous Period in Britain ...	31,815,000
Time required for the formation of 2,500 feet of Carboniferous Limestone	62,500,000
Time represented by the Continental Devonian Limestones...	125,000,000
Duration of the period represented by the Salopian (Silurian) rocks	56,000,000
Chronological value of the Unconformity at the base of the above...	12,000,000
Time required for the accumulation of the Upper Ordovician rocks	12,000,000
For the Lower Ordovician rocks	33,000,000
For the Upper and Middle Cambrian rocks	36,000,000
For the Lower Cambrian rocks	6,000,000
	704,235,000

These chronological results Mr. Goodchild offers only as a rough approximation to the real truth, not by any means as a final answer to a difficult question. The seven-hundred-million years carry us back to the beginning of the Cambrian Period, but not to the commencement of life on the Earth. The Lower-Cambrian fauna already contained representatives of all the chief forms of Invertebrate life; and probably the earliest preceding organisms existed as far away from that period as that period is from the present.

II.—GEOLOGICAL MAP OF THE BRITISH ISLES. (Edinburgh and London: W. and A. K. Johnston, 1896.)

THIS map, originally compiled by Sir Archibald Geikie, LL.D., etc., Director-General of the Geological Survey of Great Britain, has been revised and extended by Alex. Johnstone, F.G.S., etc. It is on the scale of 1,890,000 of nature, or fourteen miles to an inch. It is an excellent wall-map in its general aspect; and at the same time is plentifully inscribed, in small writing, along the coastlines with geological and mineralogical notes relating to the interior.

This new edition of the Geological Map of the British Isles, to which the "Mineralogical Geology" noticed on p. 418 is an adjunct, gives the systematic groups of formations in their several areas, strongly coloured and distinctly indicated by successive numbers. The grouping we give below. As many of the subdivisions are included in the general hard and fast colour of the group, their individuality is lost in the map, although often traceable in one or the other of the forty-five sections (either diagrammatic or generalized), which usefully occupy available spaces on the map-sheet.

The Quaternary (24, 23) is not mapped. 22, Pliocene or Crag. (21, Miocene, absent.) 22, Oligocene. 19, Upper and Middle; and 18, Lower Eocene. 17, Upper; and 16, Lower Cretaceous. 15, Upper, Middle, and Lower Oolite. 14, Lias. 13, Triassic, including Rhætic. 12, Permian (a dark-brown, printed inadvertently in two tints, above and below the latitude of Hartlepool). 11, Coal-measures. 10, Millstone Grit and Devonshire Culm. 9, Carboniferous Limestone Series. 8, Upper Devonian and Upper Old Red Sandstone. 7, Middle Devonian. 6, Lower Devonian and Lower Old Red Sandstone. 5, Silurian. 4, Ordovician. 3, Cambrian. 2, Newer Pre-Cambrian and Archæan, or Huronian. 1, Older Pre-Cambrian and Archæan, or Laurentian. If it were not for their numbering, some of the colours would probably be mistaken on the map one for another—such as 20, 19, 18, and 8, 7, 6; also 11 and 4.

Some extra care has been taken in the definition of the Igneous Rocks both on the map and in the explanatory list with the "Table of Systems and Formations," thus:—Acidic: granite, G; syenite, S; felsite, F; trachyte, T; obsidian and pitchstone, P. Intermediate: diorite, D; andesite, A; lamprophyre, L; and phonolite. Basic: dolerite and basalt, B; gabbro, Gb; picrite, Pc; serpentine, Sr; and tachylite.

This map will be found very useful in lecture-room, study, and hall.

III.—MINERALOGICAL GEOLOGY: A SYNOPSIS FOR THE USE OF STUDENTS; to accompany W. and A. K. Johnston's Geological Map of the British Isles. By ALEXANDER JOHNSTONE, F.G.S. 8vo; pp. 194, with 12 plates of fossils. (Edinburgh and London: W. & A. K. Johnston, 1897. Price 3*s.* 6*d.* separate; or 23*s.* 6*d.* with the Map, which is reviewed on p. 417.)

THE GEOLOGICAL MAGAZINE for March, 1865, contained a notice of the "Outlines of the Geology of the British Isles," accompanying Johnston's Geological Map. Since then our knowledge of the geological details has been improved by the Geological Surveyors and others, for the newer editions of the map; and the study of rock-structure, or lithology, has increased so widely and earnestly that it has become as necessary as palæontology for the right interpretation of the succession of strata, their relative age and modes of origin. Of course a knowledge of mineralogy must precede a perfect acquaintance with the structure of rocks; and, indeed, the earlier geologists thought more of minerals than of fossils.

The author states that, as the distribution of minerals is not shown on the Geological Map, he has thought it well to devote this book specially to the consideration of the mineral side of the science. He proceeds to a systematic treatment, first, of the common *elements*, and, secondly, of the common *compounds*, occurring in the crust of the Earth; and then advances to the exposition of mineralogy, including crystallography. For the character and conditions of minerals, pages 15–110 are apportioned. Systematized descriptions, with useful tables for comparisons and contrasts, give full details of each property, feature, and condition; microscopic treatment being referred to when necessary.

In Section III, pages 110–179, is given an alphabetical catalogue of the most important minerals, with concise notes as to their chief characters and their British localities. A Table of the Igneous Rocks succeeds (pp. 180–191); useful both in general and special aspects. The Aqueous and Metamorphic Rocks are succinctly tabulated.

Fossils, after all, are not neglected. A neat table shows the range-in-time of the most important animal forms, as they occur in the successive geological systems or formations; and is accompanied by twelve plates illustrative, to some extent, of the several zoological groups, from the Corals upwards, for the Palæozoic, Secondary, Tertiary, and Quaternary systems.

There is altogether a great store of mineralogical information, compendious, well-planned, and easily got at, in this valuable little book; besides its condensed and illustrated palæontological appendix. Probably, however, the students for whom this "Mineralogical Geology" seems to have been specially intended would wish that the plates had figures of minerals and rock-structures as well as fossils.

IV.—The Rocks and Soils of Grenada and Carriacou and the Agricultural Chemistry of Cacao. By J. B. Harrison, M.A., F.G.S., Government Analyst of British Guiana. 60 pages. (London: Waterlow & Sons.)

ALTHOUGH, in the main, a treatise on agricultural chemistry, this paper contains many facts of interest to the geologist. The author states that the island of Grenada, the most southerly of the Windward Group, "is purely volcanic in its origin, the only signs of upheaval being raised limestone beaches towards the extreme north." He regards it as being of more ancient date than many other of the islands of the same group. The configuration has been largely determined by denudation, and it is now difficult to fix the exact sites of the ancient craters. The lavas collected by the author during his comparatively short stay on the island comprise hornblende-andesite, hornblende-augite-andesite, augite-enstatite-andesite, augite-andesite with olivine and olivine-basalt. Full analyses of most of these rocks are given.

The soils of the island have been derived either from the lavas or from fragmental rocks of similar composition. Analyses of forty-one examples of the Grenada soils are given, and suggestions are made as to the methods by which many of these soils may be improved. The author also discusses the relations between the soils and the rocks from which they have been derived. He compares the analyses of soils derived from hornblende-andesite and from olivine-basalt (including olivine-bearing augite-andesite) with the fuller analyses of the rocks, and draws conclusions as to the relative proportions of the different constituents removed during the process of soil-formation. He takes as the basis of his calculation the assumption that alumina is not removed; and arrives at the conclusion that in one case an increase of thirty per cent. of iron-oxide has occurred. Now this may be almost said to be an impossible result. It indicates, as the author himself suggests, that alumina has been removed. A better result would probably have been attained by assuming that the total amount of iron-oxides remained constant. As the point is an interesting one, let us take the author's figures and recalculate on this basis.

	Hornblende-andesite.	Soil derived from Hornblende-andesite.	Loss.	Percentage of each constituent lost.
$Si\,O_2$	62·74	33·98	49·32	78·62
$Zi\,O_2$	trace	—	—	—
$Al_2\,O_3$	13·67	24·89	3·84	27·87
$Fe_2\,O_3$	3·39	16·98	—	—
$Fe\,O$	4·35	2·63		
$Mn\,O$	·42	·28	·31	73·34
$Ca\,O$	6·01	2·48	5·03	84·68
$Mg\,O$	1·74	2·28	·88	50·61
$K_2\,O$	1·23	·25	1·13	91·82
$Na_2\,O$	4·25	1·35	3·71	87·43
$P_2\,O_5$	·18	·14	·12	68·01
$S\,O_3$	—	·04	—	—
$C\,O_2$	—	·15	—	—
$H_2\,O$ etc.	2·02	14·55	—	—
	100·00	100·00	64·34	

From this it appears that at least sixty-four per cent. of the original material has been carried away, including seventy-eight per cent. of the silica originally present, twenty-seven per cent. of the alumina, eighty-four of the lime, ninety-one of the potash, and eighty-seven of the soda. These results are somewhat surprising, but they cannot be said to be impossible. They depend only on the assumption that the material analyzed was a fair sample of the soil formed from the hornblende-andesite, and that no iron has been removed. If iron has also been carried away, the actual amount of material lost will, of course, be greater than that indicated by the calculation.

The author was unable to examine the upraised limestones on the west coast near Mount Nesbit, but specimens from this locality were submitted to him. "These were found to consist of a shallow-water foraminiferal limestone, the most common foraminifer present being *Amphistegina*. Fragments of corals, shells, and of spines of echinoderms were also present." At the extreme north-west of the island the author himself observed beds of coral sand and mud at heights of 150 or 160 feet above sea-level.

His visit to Carriacou, though brief, gave results of great interest, and we quote his description at almost full length. "The island appears to be in the main composed of beds of fine-grained volcanic sands and tuffs. Near the town of Hillsborough, on the road towards Dumfries, I noticed a little exposure of what was either a compact tuff or a much altered lava, but I did not notice a similar rock elsewhere. As, however, I was not able to visit High North Hill and Chapeau Carré, I cannot form any definite opinion as to whether or not compact lavas occur in Carriacou. On the eastern slopes of the island, and at Belair, at an altitude of 600 feet, the tuffs of which the hills are composed are covered with layers, from ten to twenty inches in thickness, of a shallow-water foraminiferal limestone, which, upon microscopical examination, was found to be made up principally of *Amphisteginæ* and organisms apparently the remains of calcareous algæ. As far, therefore, as I was able to examine Carriacou, it appears to consist of layers of volcanic ashes, which were deposited in the sea, and afterwards covered with a foraminiferal shallow-water limestone. Later this was subjected to upheaval, with the result that part of the limestone was raised to at least 600 feet above the sea-level."

The concluding part of the work deals with the agricultural chemistry of Cacao. We hope that Mr. Harrison will be able to find the time to continue his most interesting geological observations on the West Indian Islands, for he possesses qualifications which are not often combined in the person of one observer.

V.—ON THE ORIGIN OF THE EUROPEAN FAUNA. By R. F. SCHARFF, Ph.D., B.Sc., F.Z.S., Keeper of the Natural History Collections in the Dublin Museum of Science and Art. Proc. Roy. Irish Acad., 3rd ser., vol. iv, No. 3, 1897, pp. 427–514. 8vo. (Dublin, 1897.)

THIS is a most important and instructive memoir, and full of very valuable facts; but the author has not always been able to arrange them in such a happy order that the reader may find his way readily through the great mass of materials which is here placed before him, even though aided by the headings of the chapters and sections and the general summary which the author has given (on pp. 502–506).

We venture to suggest that the title, "On the Origin of the European Fauna," is scarcely appropriate; the Memoir might more properly be described as an enlarged and improved edition of Dr. Scharff's earlier paper, "On the Origin of the Irish Land and Fresh-water Fauna" (Proc. Roy. Irish Acad., 3rd ser., vol. iii, 1894). Indeed, in the introduction of the present paper (p. 428) the author says: "As the origin of the Irish fauna forms the key to the solution of the problem which I propose to discuss, I intend to deal with it more fully than has been done, before entering on the larger subject of the general European fauna." The larger subject is, however, dealt with in a very summary and subordinate manner, and we find that Ireland really takes the "leading lady's" part. What the author calls "the *Southern migration*," meaning a migration *from* the south—and which really refers throughout specially to the British Islands, and more particularly to Ireland—has in many cases been rather a migration *to* the south, and in other cases no migration at all.

The Lusitanian element in the flora and fauna of Ireland, etc., dates probably from the Miocene. Again, a certain percentage of European Pleistocene and recent mammals have been members of the European fauna from Tertiary times, and if they migrated at all they migrated southwards. For example: The small dormouse, ***Muscardinus avellanarius*** (p. 479), is met with in a very little modified form in the Middle Miocene of Europe; the negative fact of its being absent nowadays from Ireland proves nothing at all.

Myogale moschata (p. 447), believed to have migrated to Great Britain from Siberia, has nothing to do with Siberia. It inhabits to-day *Southern* or rather South-Eastern Russia, and has been found in the Norfolk Forest-bed (Mem. Geol. Surv. 1882: "The Vertebrata of the Forest-Bed Series," pp. 98–102, pl. xvi, figs. 1–10; by E. T. Newton, F.R.S.), and a very closely allied form occurs in the Middle Miocene of Sansan and La Grive.

Again: Hippopotamus and Hyænas were already in Europe in Pliocene times, and remained there during part of the Pleistocene period, adapting themselves, as long as they were able, to the changed conditions of climate and environments.

But—apologizing for this digression—Dr. Scharff must now be allowed to speak for himself, and he is well qualified to do so.

The Divisions of the Irish Terrestrial Fauna.—"A careful study of any section of the Irish fauna and flora reveals the fact that there are in it minor groups of animals or plants which on the Continent live altogether in the north, some which inhabit exclusively the south, and others again to which no particular limit of range can be assigned. Besides these there are a small number of species peculiar to Ireland, which we need not consider here.

Taking the fauna as a whole, we find that we can establish three distinct divisions as follows:—

I. Animals with a wide distribution.
II. Animals with a Northern distribution.
III. Animals with a Southern distribution.

"I. Those of the first division comprise all animals whose origin is obscure. Many of them may, at some time or other, have been introduced by man, such as the rat or the mouse. The majority, however, I think, are of great antiquity, and their origin dates from some remote geological age. They appear to be mostly indifferent to changes of temperature, and many thrive equally well in cold and in hot countries. The small brown slug (*Agriolimax lævis*), the painted lady butterfly (*Vanessa cardui*), and the barn owl (*Strix flammea*) are familiar examples.

"II. To the animals of the second division belong those of which we have distinct evidence, from their geographical range, that they are of Arctic origin. As I hope to prove later on, they have arrived in Ireland directly from the north. Among the mammals the reindeer (*Rangifer tarandus*, Linn.), which formerly inhabited this country, the Irish stoat, and the Irish hare form part of this northern section. The beetles *Pelophila borealis* and *Blethisa multipunctata*, the butterfly *Cænonympha typhon*, the small shell *Vertigo alpestris*, as well as the common stickleback (*Gasterosteus aculeatus*), have all reached Ireland from the north.[1]

"III. The third division includes the bulk of the Irish fauna. In the first place, we have to consider those animals whose birthplace appears to be in South-Western Europe, then we have those which originated in the South or South-Central Europe, whilst there are others which came to Ireland from the south-west, though they may primarily have migrated there from Central Asia across Southern Europe. No very strict line can be drawn between the animals of South-Central and those of South-Western European origin, but we may with Edward Forbes[2] regard the most southern as the oldest. A good many of these are altogether absent from England, whilst they are mostly confined to the west coast in Ireland. Taking all the Irish southern types into account, we find that the majority are confined, in the remainder of the British Isles, to the south-western parts of England and Wales. In some cases they appear again in the extreme north of England and in Scotland, without, however, being known in the intermediate tracts.

"We can subdivide this southern fauna, therefore, into a south-western and a south-central one: to the former belong the well-known bullfinch (*Pyrrhula Europæa*), the dipper (*Cinclus aquaticus*), and the natterjack toad (*Bufo calamita*); also the following

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[1] Among the Irish plants we have some species, such as *Spiranthes Romanzoviana*, *Eriocaulon septangulare*, and *Sisyrhynchium angustifolium*, which appear to belong to the same division.

[2] "The Connection between the Distribution of the existing Fauna and Flora of the British Isles with the Geological Changes which have affected their area": Mem. Geol. Surv., vol. i, 1846.

Mollusca, *Geomalacus maculosus*, *Pupa Anglica*, *Helix fusca*, and *H. pisana*; the beetles, *Rhopalomesites Tardyi*, *Eurynebria complanata*, and *Otiorrhynchus auropunctatus*. Among the Irish woodlice, *Platyarthrus Hoffmanseggii* belongs to this first division, as well as the Hemipteron *Lygus atomarius* and the millipede *Polydesmus Gallicus*. Some of the species peculiar to Ireland have their nearest relatives confined to the south-west of Europe, e.g. *Tegenaria Hibernica*, which is closely related to the Pyrenean *Tegenaria larva*.[1]

"The badger (*Meles taxus*), is for our purposes a South European type of the second subdivision, though it originated probably in Asia. The following Mollusca also belong here: *Helix aculeata*, *H. rufescens*, *H. virgata*, *H. acuta*, *H. nemoralis*, and many others; also the beetle *Strangalia aurulenta*."[2] (p. 430.)

On the Accidental Dispersal of Animals and Plants.—Referring to the accidental means of dispersal of animals and plants Dr. Scharff observes (p. 434): "As regards Ireland, I believe the animals derived from accidental or occasional means of dispersal amount to five per cent. of the whole fauna at the most. Land and freshwater mollusca are generally looked upon as particularly liable to accidental dispersal." After quoting the experiment of Baron Aucapitaine, who, having immersed living *Cyclostoma elegans* for a fortnight in the sea, found that almost all of them survived, he adds: "Supposing Ireland had been stocked in this manner with (land-)shells, we should expect operculate species, or even such which provide themselves with a membranous diaphragm during winter to be abundant. But this is not the case. Neither *Cyclostoma elegans* nor *Helix pomatia*, the two species which were experimented on, inhabit Ireland, though both occur in England and in France. Moreover, as a matter of fact, the shells of the former species have again and again been washed ashore within recent years upon the Irish coast; but though this must have been going on for centuries, yet *Cyclostoma elegans* has not established itself in this country. The only Irish operculate land-shell (*Acme lineata*) lives permanently underground, and is therefore less liable to accidental transportal than the other species."

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"It is fully admitted that many animals and plants are easily transported to new countries by accidental means, or voluntarily by man, but in most cases they have not been able to retain a permanent footing in their newly-adopted home. There are innumerable instances on record of species having been planted on spots where they did not previously exist, and the introducers claim that it is highly interesting to watch their progress. In the great majority of cases we find that, fortunately, these species utterly vanish after a few years." (p. 435.)

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[1] The following Irish plants may be mentioned: *Arbutus unedo*, *Euphorbia Hiberna*, *Simethis bicolor*, and *Sibthorpia Europea*.

[2] *Cotyledon umbilicus*, and other plants, probably belong to this type.

"These few instances will suffice to show that it is by no means so easy as it is generally supposed, to establish an animal in an area which it was previously not known to inhabit, and that really only a very small percentage of the Irish fauna can be due to an occasional means of dispersal." (p. 436.)

On the former Land-connection between the British Isles and the Continent.—After citing numerous authors on the former land-connection between the British Islands and the Continent, the author remarks:—"It is difficult enough to imagine how, under the present configuration of Ireland, the mammoth, the wolf, and the bear reached the island. But when we come to the less conspicuous Invertebrates, we are confronted with cases which give us even less chance of escaping from the inevitable assumption of a land-connection with the Continent. How are we, for instance, to suppose that earth-worms reached Ireland, or *Testacella*, a slug-like mollusc, which spends its entire existence under ground, or *Platyarthrus Hoffmanseggii*, a blind wood-louse, which also lives below the surface of the soil, in the nests of ants, unless by slow migration on land?" (p. 438.)

Having decided that the bulk of the Irish fauna migrated to Ireland on land, the author proceeds to consider what was the nature of that land-connection, and by means of a diagram he shows that the old land-surface of the British Isles embraced the entire extent of the coast platform to the 100-fathom line from the Shetlands, Orkneys, and the Western Isles to the coast of France south of Belle Isle.

The Lusitanian Flora.—Dr. Scharff points out that the Lusitanian flora and fauna are not peculiar to Ireland. "Fragments of it occur undoubtedly in the south-west of England, in the Channel Islands, and along the west coast of France. That flora migrated, therefore, along the ancient sea-border from the south, across the south-west of England, or the land that lay beyond it." (p. 440.)

The Northern Immigration of Plants and Animals.—"The northern animals and plants undoubtedly came across from Scotland, and in the county of Londonderry, which part of modern Ireland they first touched, they still are more common than in any other portion of the country. But they did not originate in Scotland. . . . . It was from Scandinavia that our northern animals and plants came. Many of them, possibly, originated there, but the home of others lies, no doubt, far beyond even the confines of Scandinavia in the Arctic regions. Thus Ireland had, as we have seen, two land-connections with the Continent of Europe—one by way of the south of England to France, and the other by way of Scotland to Scandinavia."

Effect of the Glacial Period on the Pre-existing Fauna and Flora.—After quoting the views of extreme glacialists who hold that in the Glacial period the cold was so intense that all life was exterminated, the author adds—"The evidence as to the existence, however, of a fauna in Southern England, at any rate during the Glacial Period, is so overwhelming, that I can hardly believe that many naturalists will accept Professor Geikie's views. Nevertheless, there are certainly some who do, and among them Mr. Clement Reid, author of the 'British Pliocene Deposits,' who remarks that 'in the Britain of the present day we may study the repeopling of a country over which everything had been exterminated!' . . . . The opinions expressed by zoologists, botanists, and geologists are overwhelmingly in favour of the Post-Glacial age of the present British fauna. It is believed, even by most of those who admit that the British Islands were inhabited by a very similar fauna and flora in Pre-Glacial times, that a vast destruction of animal and vegetable life took place during the Pleistocene epoch, and that very few, if any, species survived the change of climate brought about by the Glacial period." "As I have already indicated," says Dr. Scharff, "I do not share these views." The author then proceeds to give his own conclusions on this point.

Geographical Conditions prior to the Glacial Period.—"At the commencement of the latter half of the Pliocene epoch, or we might say about the time of the deposition of the Red Crag, the Atlantic was closed in the north by a continuous land-connection between Northern Scandinavia, Spitzbergen, Franz Joseph's Land, Northern Greenland, and Arctic North America. The Pacific was likewise separated from the Arctic Ocean by a land-barrier between Alaska and Kamtschatka. The Arctic fauna and flora were thus enabled to spread into Northern Europe and North America. England was also connected with France and Ireland, and Scandinavia and Ireland with Scotland. A marine expansion from the White Sea then spread across Northern Russia into the North European plains, and the sea thus formed, which I proposeto call the North European Sea, joined the united basins of the Aralo-Caspian and Black Seas." (p. 445.)

Movements of the Faunas and Floras.—"The Siberian fauna was, therefore (at that time) unable to enter Europe, while the more southern Central Asiatic fauna continued to migrate into Southern Europe, as in Miocene and early Pliocene times, by a land-connection which joined Asia Minor and Greece. A gradual retreat of the North European Sea to the north opened up a passage in Eastern Europe by which the Siberian fauna poured into Central Russia, Germany, France, and England. There is distinct geological evidence that this vast migration of the Siberian fauna and flora occurred after the deposition of the Lower Continental Boulder-clay. The advance-guard composed of mammals arrived in England during the deposition of the Forest-bed. This marks, therefore, not only the time of the first retreat of the North European Glacial Sea, but also that of the disconnection of England and Ireland, since none of the Siberian mammals entered the latter.

"Meanwhile the Central and South Asiatic mammals, which, as I mentioned, had rambled into Southern Europe, spread into Northern Africa and Western Europe along the shores of the Mediterranean. Many subsequently invaded Central Europe, and also spread north into Great Britain and Ireland. These and the Arctic mammals mostly retired before the Siberian invaders. Hence the purely

Arctic species had also reached Western and Central Europe before the advent of the latter." (p. 445.)

"In speaking of the Irish Arctic fauna, we must not, as so many naturalists have done, confuse animals of an Arctic with those of a Siberian origin. It is very important to distinguish these two elements, both of which are present in the fauna of Great Britain, though only the former has reached Ireland."

Siberian Mammals in Britain.—"In order to show the importance of the Siberian element in the English fauna, I will give a list of the species of the mammals which have migrated to Great Britain from Siberia, marking those with an ° which still exist or only became extinct in historic times in the country. There is no reason to suppose that any of the latter became extinct and have since been reintroduced.

Siberian Migrants.

Canis lagopus.
Gulo luscus.
*_Mustela erminea._
*_M. putorius._
*_M. vulgaris._
*_Sorex vulgaris._
(? _Myogale moschata_).[1]
Lepus diluvianus.
*_L. Europaeus._
Lagomys pusillus.
*_Castor fiber._
Cricetus songarus.
Sphermophilus Eversmanni.
S. erythrogenoides.
Myodes lemmus.
Myodes torquatus.
*_Mus minutus._
*_Arvicola agrestis._
*_A. amphibius._
A. arvalis.
*_A. glareolus._
A. gregalis.
A. ratticeps.
Equus caballus.
Antilope saiga.
Ovibos moschatus.
Alces latifrons.
A. machlis.
Rangifer tarandus.

"We have geological evidence that most of these twenty-nine species of mammals emigrated from Siberia to Europe across the Steppes of Southern Russia. Along with them came a large number of other forms of life, and also plants; and as we advance eastward from England, we meet with them in increasing numbers to the present day. But not only on the Continent do we find these survivals of the vast Siberian migration, which has been so ably described by Professor Nehring[2]; no less than ten species still live in Great Britain (including the recently extinct beaver). On the other hand, not more than three of the species mentioned on the list above have been found fossil in Ireland, and only one still survives. It should be remembered that these three species, viz., *Mustela erminea*, *Equus caballus*, and *Rangifer tarandus*, occur in Ireland in varieties distinct from those found in Central Europe; and on this and other grounds, I believe that they came by a different route from those found in England, and that Ireland was not connected with England at the time of the arrival of the Siberian emigrants in the latter country." (p. 448.)

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[1] *Myogale moschata* should be removed from this list; it belongs to South-Eastern Russia (see remarks on p. 421, ante).

[2] "Geographische Verbeitung d. Säugethiere in dem Tschernosem Gebeite," etc. 1891.

"We have still to inquire into the causes which led to the Siberian migration, and to ascertain the geological period during which it took place. In order to arrive at a more satisfactory conclusion on these problems, it is of some moment to study the extinct fauna of Siberia." (p. 449.)

"Since Tcherski has shown that Western Siberia is largely covered by fresh-water deposits, the assumption that the Aralo-Caspian had been in direct communication with the Arctic Ocean as recently as the Pliocene epoch can no longer be maintained; but, as we shall see presently, there is some evidence in favour of a European connection between the two seas." (p. 453.)

(*To be continued in our next Number.*)

CORRESPONDENCE.

TRESPASSERS, BEWARE!

Sir,—I am grateful to my "kalikali" colleague, Mr. F. A. Bather, for pointing out that (in common with the more learned palæontologists who have recently prepared a Synopsis and a Revision of the Cystoidea) I had overlooked the fact of a new name having been proposed for Hall's *Echinocystis* in the last edition of his friend Mr. S. A. Miller's Catalogue.

In regard to *Discocystis*, a defence of the name would involve a greater trespass into the domain of the Cystoidea than I was recently forced to make in relieving the term *Echinodiscus* from double duty in Echinoderm nomenclature. A review in the current number of *Natural Science* helps me to resist the temptation; for the reviewer, whose information is apparently of the best, deplores the brief treatment of the Cystoidea in the new Guide to the Fossil Invertebrata in the British Museum, although "our National Museum possesses not only a fine collection of those rarities, but an officer well qualified to deal with them." J. W. Gregory.

TRINUCLEUS SETICORNIS.

Sir,—It is satisfactory and instructive to find in last month's Geological Magazine Mr. Marr so clearly indicating his early mistake about the range of *Trinucleus seticornis*, for he mentions in his criticism of my remarks that in 1883 he had stated that this species was nowhere found in the Upper Bala, while in 1885 he was led to call some Upper Bala beds in South Wales the *T. seticornis* beds, on account of its abundance in them. After this presumably conscious acknowledgment of an error, I am, therefore, surprised to find Mr. Marr much troubled in mind because I naturally considered that his statement of 1885 considerably qualified, or even negatived, his earlier one of 1883. Perhaps Mr. Marr wishes to make another correction in his opinions published in 1885.

With regard to the identification of this protean species of trilobite I exceedingly regret that infallibility cannot be claimed as a prerogative by eminent geologists, or even by "very competent palæontologists," at any time of their life, and that consequently Mr. Marr and I have to suffer for their sins and misfortunes in failing to examine or understand Hisinger's type. It is to be hoped that we shall not have to suffer more in this or any other respect by the labours of the new "very competent palæontologist" to whom Mr. Marr refers.

But with regard to the right or wrong determination of this species of *Trinucleus* I can speak with a very much freer conscience than Mr. Marr, for the genus so far seems conspicuous by its absence from the Keisley Limestone (as I have stated in my paper which Mr. Marr criticizes), and therefore I have had no question of its specific identification to decide for myself in this case. Mr. Marr, therefore, appears to have been singularly unlucky in his choice of a weapon with which to attack my conclusions, and it is a pity his solicitude for the readers of this Magazine has led him to omit his criticisms on the "many statements" and "questions of detail" in my paper with which he disagrees.

F. R. Cowper Reed.

Cambridge, *August* 16, 1897.

OBITUARY.

SIR AUGUSTUS WOLLASTON FRANKS, K.C.B., ETC.

Born 1826. Died May 21, 1897.

Sir Augustus Wollaston Franks, K.C.B., D.C.L., F.R.S., Pres.S.A., F.G.S., Trustee of the British Museum, late Keeper of British and Mediæval Antiquities and of Ethnography at the British Museum, was born at Geneva in 1826, and educated at Eton and Trinity College, Cambridge, taking his M.A. degree in 1852. His taste for the beautiful in works of art, and his appreciation of the niceties, peculiarities, and fantasies of artists, whether the results were produced with the inspiration of genius or by handicraft and labour, led him to collect largely in each department of artistic work, and fortunately his ample means enabled him to do so. With munificent liberality he gave many valuable collections to the National Museum at Bloomsbury. It was thus that, not only theoretically, but practically and personally, he was acquainted with the extensive and many-sided collections of antiquities and ethnographic exhibits under his keepership. He was not a mere official custodian, but a cultured connoisseur, and a high-class authority on all points connected with the scientific and historical aspects of the materials or collections in his charge. Necessarily his study of mediæval remains kept him in touch with those of prehistoric age in the British Collection which was under his care; and, indeed, of these there are many objects of human workmanship dating from extremely early times. Contemporary with these were similar productions in European and other countries. These are largely represented in the British Museum by the "Christy Collection," which Sir Wollaston Franks augmented by successive gifts of similar well-assorted examples from many localities. Indeed, this notable department in the Museum well deserves now to be called the "Christy-Franks Collection."

In March, 1864, Mr. Henry Christy invited a party of his friends, interested as antiquaries and geologists, to examine some of the bone-caves on the Vezère, Dordogne district, in the south of France, which, with his friend Edouard Lartet, he had for some time been investigating with great care and at considerable expense. The party comprised Mr. W. J. Hamilton (President of the Geological Society), Professor Rupert Jones (Assistant Secretary of the Geological Society), Sir Douglas Galton, Sir John Lubbock, Sir John Evans, and Sir A. W. Franks.[1] Not only had the last-named already interested himself in Henry Christy's researches in the ethnographic relationship of various textile fabrics, which had led him to Mexico, and in that country to the observation of stone implements, but Sir A. W. Franks heartily joined Christy in the study of stone implements, and of those who made and used them, whether ancient peoples, recent savages, or living workmen in some modern trades and manufactures. Together with Dr. Hugh Falconer, he aided H. Christy and E. Lartet in planning their great work, "Reliquiæ Aquitanicæ," which was intended to comprise descriptions of all the Dordogne caves and their contents. Unfortunately the death of both Christy and Lartet circumscribed the work within smaller limits, for no more caves were worked out by them, and but few plates were subsequently added to the eighty or more already lithographed for its illustration. It is noticed, we see, in the preface of the book that, "In bringing together and arranging the varied materials supplied by friends at home and abroad desirous of making the 'Reliquiæ Aquitanicæ' useful in Archæology and Anthropology, the directing counsels of Mr. A. W. Franks, F.R.S., have been constant and efficient, like his courtesy and knowledge."

He took charge of the "Christy Collection" at 103, Victoria Street, S.W., for some time before it was transferred to the British Museum; and he individualized the specimens with accurate drawings by his talented assistants—first, Mr. T. K. Gay and subsequently Mr. Charles Read. The latter worthily succeeded Sir Wollaston on his resignation, in 1894, as Keeper of British and Mediæval Antiquities and Ethnography in the British Museum.

It was with great caution that Sir Wollaston exercised his judgment as to the authenticity of implements of stone and their relative age. He was not an enthusiast in the subject of the great antiquity of the Human Race. Possibly, had he been induced to give more leisure to the study of the geological aspect and details of the subject, he might have become cognisant of the value of Sir Joseph Prestwich's researches in the geological age of some of the older groups of flint implements, especially of those collected with earnest and intelligent care at Ightham, in Kent, by Mr. Benjamin Harrison.[2]

Sir A. Wollaston Franks contributed largely to scientific literature, especially by memoirs and notices in the Transactions and Proceedings of learned societies. He has greatly enlarged the knowledge of antiquities and their real relationships, not only by original research, but by his willing advice and ready information to inquirers, whether in London or the provinces. He has bequeathed all his most valuable collections to the British Museum. He was elected to the Royal Society in 1854. For many years an active and valued Fellow of the Society of Antiquaries, he was elected Director of the Society in 1858; subsequently for some years he was Vice-President, and eventually became President in 1892. T. R. J.

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[1] Quart. Journ. Geol. Soc., vol. xx, 1864, p. 444; and "Reliquiæ Aquitanicæ," part xii, 1873, p. 161.

[2] See Quart. Journ. Geol. Soc., xlv, 1889, pp. 270–297, pls. ix–xi; and Natural Science, vol. v, p. 269, Oct. 1894.

SAMUEL ALLPORT, F.G.S.

Born January 23, 1816. Died July 7, 1897.

By the death of Mr. Samuel Allport we have lost one of the pioneers in microscopic petrology. He was born at Birmingham on January 23, 1816, being descended from an old Staffordshire family, and was educated at King Edward's School in that town. For some years he was in the office of Rabone Brothers, and then went to Bahia in South America as business manager for another firm. There he married a Spanish lady, but had the misfortune to lose his wife within a year. On his return to England, after an absence of eight years, he took a share in a business on Snow Hill, and devoted all his spare time to scientific work. He had already become an ardent geologist, and his first paper, published in the Quarterly Journal of the Geological Society for the year 1860, was on the discovery of some fossil remains near Bahia (vol. xvi, p. 263). But he was quick to perceive the importance of studying the structure of rocks by the method which a few years before had been initiated by Dr. Clifton Sorby. He prepared his own specimens, and acquired such skill that in the writer's opinion, though he may have been equalled, he has never been surpassed in this craft by any English worker. In course of time he formed a large collection of both rock-specimens and microscopic slides, to the study of which he devoted himself with great energy. The business in which he was a partner unfortunately was not prosperous, and had to be abandoned about 1880, when he was appointed librarian to the Mason College. Though circumstances had compelled him to sell his collection some little time before to the British Museum, he set to work energetically to form another, and continued at his favourite study. But now health began to fail; any continuous mental exertion brought on distressing attacks of vertigo, and in 1887 he was obliged to retire from his post at the Mason College. After this, though he was still able to continue his geological reading, and to work quietly with his microscope, he was unfit to bear the strain of writing a paper. His last effort, a valuable report on the effect of Contact Metamorphism exhibited by the Silurian Rocks near the town of New Galloway (Proc. Roy. Soc., xlvi, 193), could not have appeared without collaboration. Increasing ill-health and grave anxieties unhappily cast a shadow over Allport's later years, but all was endured with quiet patience and gentle fortitude. Some three years ago he quitted Birmingham for Cheltenham, where he died after a very short illness on July 7, his mind happily remaining unclouded till near the end.

Allport was not a voluminous writer. He published rather less than twenty papers in all, most of which appeared in this Magazine, or in the Quarterly Journal of the Geological Society. In the former those on the South Staffordshire Basalts (1869), the Wolf Rock Phonolite (1871), and the Pitchstones of Arran (1872) may be specially mentioned; in the latter the highly important papers on the British Carboniferous Dolerites (1874), on the Metamorphic Rocks surrounding the Land's End Granite (1876), on devitrified Pitchstones and Perlites from Shropshire (1877), and on the Diorites from the Warwickshire Coalfield (1879). He became a Fellow of the Geological Society in 1869, was awarded the Wollaston Fund in 1879, and received the Lyell Medal in 1887.

We cannot measure the value of Allport's work by its quantity. His extreme care as an observer, alike in the field and with the microscope, his wide range of knowledge, for he was far more than a petrologist, his strictly inductive habit of mind, give to that work exceptional solidity and permanent value. Though he was compelled to feel his way, as a man in an unknown forest, he was one of the safest of guides. To such a patient, accurate observer and sound, cautious reasoner, flashy hypotheses presented no charms, and Samuel Allport did much to liberate petrology from such errors as making geological age a factor of importance in the classification of igneous rocks. Amiable, courteous, and openhanded, he was beloved by those who had the good fortune to know him. Absolutely free from all petty jealousies, he was the most generous of helpers to all younger men who were attracted to his favourite study. Whatever he knew was at the service of others, and no man owes him a deeper debt of gratitude than the writer of this tribute to his memory.

T. G. B.

PROFESSOR S. A. B. LUNDGREN.

BORN FEBRUARY 19, 1843. DIED JANUARY 7, 1897.

THE death of Professor Lundgren has removed from Sweden a valued worker in the field of geological science, and in him the University of Lund has lost one of its most energetic and able lecturers.

Sven Anders Bernhard Lundgren was born at Malmö in Scania on the 19th of February, 1843. He seems to have passed the early days of his life in his native town, but became a student at the University of Lund in the autumn of 1860.

He worked diligently at all the subjects then considered essential for the degree in Philosophy, but at an early stage in his career he showed a marked preference for natural science. He especially distinguished himself in zoology and botany, and was a very fair chemist.

Geology was not at that time recognized as a distinct subject in the examinations of the University; nevertheless, Lundgren attended some lectures on that subject given by N. P. Angelin. He took his examination for the degree of "Kandidat" in 1864, and proceeded to the final degree of Doctor in Philosophy in the following year. The treatise that he wrote for this occasion was on a geological subject, namely, "A contribution to the knowledge of the geological relations of the Saltholm Limestone."

The following September Lundgren accompanied Professor E. Hébert on a geological tour in the Scanian Mesozoic districts. It was in this trip that he made his first acquaintance with the district whose geology was to be the subject of his most important work.

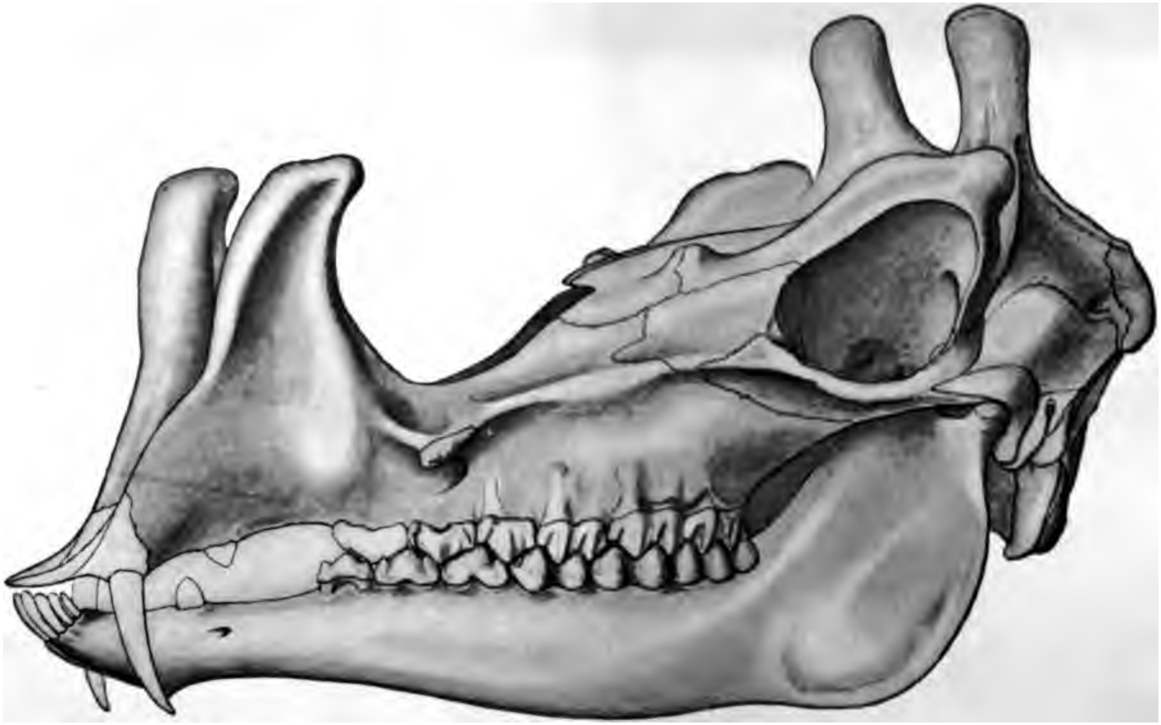
From that time he appears to have turned his attention to geology entirely, and in June, 1867, was appointed "docent" in Palæontology. At this time the Professorship of Zoology at Lund was taken to include that of geology, and was held by Professor Otto Torell, the present chief of the Swedish Geological Survey. When Professor Torell vacated the Chair of Zoology in 1880 the two professorships were separated, and Lundgren was appointed first Geological Professor in the University of Lund. Previous to receiving this appointment he had made several journeys abroad, and had become thoroughly acquainted with the Mesozoic Geology of Western Europe. Of Lundgren's activity as a teacher in the University of Lund little need be said; the very existence of the Geological Institute will remain as a lasting memorial of his untiring zeal and devotion to the cause of his favourite science.

As a lecturer he seems to have had a wonderful power of interesting his audience in his subject, partly, no doubt, because he could speak of most important matters from personal observation.

His best known geological works are those which treat of the Mesozoic Rocks of Scania, and it must not be forgotten that it is to Lundgren that we are indebted for the working out of the highest Cretaceous (Danian and Senonian) beds of the South of Sweden, and he also showed the true relation of the Saltholm Limestone to the Faxoe Limestone. Another great work of his was published in 1885 "On the Brachiopoda of the Swedish Chalk." Among other papers was "A treatise on the Mollusca in the older Swedish Mesozoic Deposits," published in 1881, and the third part of the well-known "List of the Fossil Faunas of Sweden." This part dealt with the fauna of the Swedish Mesozoic deposits, and for it Lundgren was mainly responsible. He published two papers on the Palæontology of Spitzbergen, one in 1883, the other in 1887; the material for these was supplied by Nathorst and De Geer, who had collected it in the expedition of 1882. Lundgren's latest geological work was published in 1895, "On some Jurassic Fossils from Cape Stewart in Eastern Greenland." These were collected in the Danish Expedition of 1891–2.

In the spring of 1895 his health began to give way, although it is probable that he had for some time previously been threatened with the disease to which he finally succumbed. He died on the night of January 7 in the present year. G. L. E. (Translator).

(For these facts I am greatly indebted to the obituary notice written by Dr. Törnquist for the Geological Society of Sweden.—G. L. E.)



Skull of Male of *Protoceras celer*, Marsh.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. X.—OCTOBER, 1897.

ORIGINAL ARTICLES.

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I.—The Skull of *Protoceras*.

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.A.

PLATE XIX.

THE genus *Protoceras*, described by the writer in 1891, from the Miocene of South Dakota, is now known to include some of the most interesting extinct mammals yet discovered. It likewise represents a distinct family, and thus deserves careful investigation and description.[1] Before this discovery, no horned artiodactyles were known to have lived during Miocene time, and *Protoceras* is thus the earliest one described. The type-specimen, moreover, had a pair of horn-cores on the parietals, and not on the frontals as in modern forms of this group. The animal was apparently a true ruminant, nearly as large as a sheep, but of more delicate proportions.

The first skull found, the type-specimen of the genus *Protoceras*, belonged to a female, as later discoveries demonstrated. The skull of the male proved still more remarkable, and especially resembles the male skull of the Eocene Dinocerata in having several pairs of horn-cores or protuberances upon the head, a feature hitherto unknown among the Artiodactyla. It is an interesting fact, moreover, that one pair of these horn-cores of *Protoceras* is on the maxillaries, as in *Dinoceras*, while the posterior pair, as in that genus, is on the parietals.

The resemblance in the two skulls is further enhanced by the absence of upper incisors and the presence of large canine tusks, forming together a striking similarity in important features, between skulls pertaining to animals of two distinct orders, and from widely different geological horizons. The skull of the male *Protoceras* is shown in Plate XIX, and that of *Dinoceras* in the text below.

It is a noteworthy fact, that in still another order of ungulate mammals, the Perissodactyla, horn-cores in pairs early made their appearance, although none are known in the recent forms. One of the earliest instances is seen in the genus *Colonoceras* from the Middle Eocene, which had rudimentary protuberances upon its nasal bones. The gigantic Brontotheridæ of the Lower Miocene all had prominent horn-cores on the maxillary bones, somewhat like those of the male *Protoceras*. One of the most unexpected examples, however, in this order, appears in the Miocene genus *Diceratherium*. This animal, although a true rhinoceros, had a pair of horn-cores on the nasal bones, while all other rhinoceroses, living and extinct, are either without horns or have them on the median line. In short, horns in pairs are unknown in existing mammals, except in the artiodactyles, an order of later development, but now the dominant group of ungulate mammals.

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[1] American Journal of Science, vol. xli, p. 81, January, 1891; vol. xlvi, p. 407, November, 1893; and vol. iv, p. 165, September, 1897.

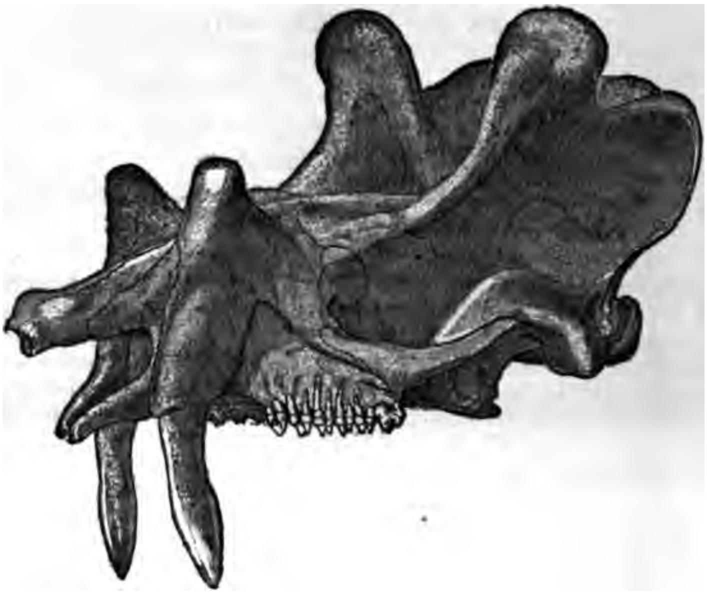

Fig. 1.—Cranium of *Dinoceras mirabile*, Marsh. Type; seen from the side. One-seventh natural size. Middle Eocene: Wyoming Territory, U.S.A.

The Skull of the Male.

The skull of the male *Protoceras*, in addition to the marked characters above mentioned, has others of equal interest, if not of still greater taxonomic value. The general appearance of the adult male skull is well shown in Plate XIX, accompanying the present article.

Aside from the various horn-cores and protuberances upon the skull, the next most notable feature is the very large, open nasal cavity, a character which pertains to both sexes, and to the entire family of the Protoceratidæ. This peculiar feature is of even more importance than the horn-cores, judging from its functional significance, and its rarity in more recent forms of artiodactyles. It indicates clearly in the living animal a long flexible nose, if not rue proboscis. The only existing ruminant thus equipped, known the writer, is the rare Saiga antelope (*Saiga Tartarica*, Gray) ›m the steppes of Siberia. A comparison of a *Protoceras* skull th that of the Saiga antelope plainly indicates, in the nasal region, identity of function doubtless accompanied by a similar nasal pendage, and it is of interest to find such evidence of this feature a representative from the Miocene of North America.

The general form of the male skull of *Protoceras* is long and rrow, with the facial portion much produced. The prominent rn-cores, however, serve to obscure its real shape, which is more parent in the female skull. Seen from the side, as in Plate XIX, appears unusually low, with the orbit well behind. Its greatest dth is in the posterior region.

The premaxillaries are small and edentulous. Their anterior :remities are depressed, and more or less expanded transversely, in typical ruminants. The outer suture between the premaxillary d maxillary is short, and persistent even in adults. Seen from ow, the premaxillaries form together the palatal surface in front the maxillaries, each sending backward a narrow process which inserted between the divergent maxillary plates. The anterior atine, or incisive, foramina are situated on the sutures separating › two bones.

The maxillary bones are greatly developed, being much the gest elements of the skull, as shown in Plate XIX. The anterior :remity supports the large descending canine tusk, and is hollowed : to contain its base. The high anterior horn-cores are formed :irely of the maxillary bones, which are greatly strengthened to pport them. These horn-cores are more or less recurved, and in › type-species their summits are triangular in outline. In another ecies, *Protoceras nasutus*, the summits of the maxillary horn-cores › oval in section. Another characteristic feature of the genus *otoceras*, which is seen in both sexes, is a strong lateral ridge :ending nearly horizontally across the outer face of the maxillary ne, and continuing backward to the orbit. In the male skull re described, this ridge begins near the base of the maxillary rn-core, and, expanding into a prominent tubercle, just above the :orbital foramen, continues backward by an upward curve, and sses into the ridge of the malar bone extending beneath the orbit. both sexes, the anterior portion of this lateral ridge, with its aracteristic tubercle, forms the lower border of a deep, well-marked pression, which probably contained a gland. In Plate XIX this rity is well shown behind the maxillary horn-cores, just below the nt where the superior border of the skull is lowest.

The nasal bones join the maxillaries above, and complete the sterior border of the large narial opening. They are of moderate gth on the median line, and their free anterior extremities are te short. These bones are much expanded transversely, and at ir widest part articulate with the lachrymals. All the sutures rounding the nasals are distinct, and this is true also of their dian suture. Their upper surface is convex, both transversely and longitudinally, and is marked by two deep grooves, which lead backward to the supra-orbital foramina in the parietals.

The frontals, which bound the nasals behind, are large massive bones, much wider than long. The suture which unites the two frontals is distinct, and cuts the naso-frontal suture nearly at right angles. At the lateral junction of the frontal and nasal, there is on each side a low tuberosity, resembling a diminutive horn-core, and these form the third pair of elevations on the skull. At the postero-external angle of the frontals, above the orbits, another pair of much larger protuberances is seen, and the summits of these are widely expanded transversely. The upper surface of the frontals is rugose, and the deep grooves already mentioned are characteristic features.

The parietal bones are much smaller than the frontals, and are separated from them by a distinct sigmoid suture. These bones support the posterior pair of horn-cores. The general form and position of these elevations on the male *Protoceras* skull are represented in the accompanying plate, but they differ in each species. Behind these horn-cores there is a low sagittal crest separating the deep temporal fossæ. Back of the parietals is the short supra-occipital, which forms a weak lambdoidal crest bounding the temporal fossæ behind.

The inferior portion of each fossa is formed by the squamosal, which covers the lower half of the brain-case, and joins the parietal above by a distinct suture, as shown in Plate XIX. The squamosal sends forward a short zygomatic branch, which fits into a notch in the posterior part of the malar. There is a distinct postglenoid process. The tympanic bone is not dilated into a definite bulla, but below the auditory meatus forms a short descending process. The periotic is behind the tympanic, separated from it above by the post-tympanic process of the squamosal, and below by an open suture. It is wedged in between the latter bone and the strong and elongate paroccipital process of the exoccipital.

The orbit is closed behind by a descending process from the frontal, which meets the upper branch of the malar. Its lower border is bounded by the malar, which in front joins the lachrymal above and the maxillary below, as shown in Plate XIX.

The lachrymal is bounded in front by the maxillary, above by the nasal and frontal, and below by the malar and maxillary. The lachrymal foramina are two in number, well within the orbital border. The orbits are large, suboval in outline, and widely separated from each other. Their posterior position is a characteristic feature of the genus *Protoceras*.

The Base of the Skull.

The narrow occiput, surmounted by the supra-occipital, is a noteworthy character. The widely expanding orbits greatly increase the width of the skull in this region, and from here forward its wedge-like shape is a striking feature. The basi-occipital and the basisphenoid bones are firmly co-ossified, the suture between them being indistinct. In front of the latter bone is the parasphenoid, separated from it by a well-marked suture, and passing forward above the vomers, which are here distinct. The pterygoids are attached to the posterior border of the palatines, and above to the alisphenoids. There is no distinct alisphenoid canal.

The palatine bones are narrow, and bound in front the posterior nares, which extend forward to near the middle of the penultimate molars. The maxillary plates form the roof of the palate forward to the premaxillaries. At their narrowest portion, they are deeply grooved for the approaches of the palato-maxillary foramina, which are situated somewhat in advance of the second premolars. The maxillary plates are separated in front along the median line, to receive the posterior branches of the premaxillaries, and on the suture between the two elements the anterior palatine foramina are in their usual position. The turbinal bones were apparently quite small.

The Lower Jaw.

The lower jaw is well represented in Plate XIX. It is long and slender, especially in front, thus corresponding to the skull. The condyle is broad and strongly convex above. The coronoid process is very short, and its summit is but little higher than the condyle. The angle is rounded and well developed. The ramus expands downward and is thickened beneath the molar teeth, and has a sharp upper edge along the diastema between the first and second premolars. It again extends downward at the symphysis, becoming more robust to support the front teeth.

The Dentition.

The dentition of *Protoceras* is of the early ruminant type, as shown by the short-crowned, selenodont molar series. The dental formula is as follows:

Incisors $\frac{0}{3}$, Canines $\frac{1}{1}$, Premolars $\frac{4}{4}$, Molars $\frac{3}{3}$.

In the male skull, the upper canines are well developed, as shown in Plate XIX. They are compressed and somewhat trihedral in transverse section, and in life formed efficient weapons of warfare. The first upper premolars, a short distance behind, are small compressed teeth, each with two roots; and after a still longer diastema, the second premolars begin the continuous series. The second and third upper premolars each have a large outer cusp and an inner cingulum, while the fourth has a distinct inner crescent. The superior molars have all short crowns and the double crescents of true selenodont dentition, with a well-developed inner basal ridge.

The teeth of the lower jaws of *Protoceras* are indicated in Plate XIX, and the full series is shown. The three incisors are directed well forward, and diminish in size from the first to the third. The still smaller canine is situated close to the last incisor, and is similar in form. A long diastema follows, and gives the upper canine freedom of motion. The first premolar is somewhat similar to the corresponding one above, but is larger and directed more forward. A still longer interval separates the first and second lower premolars, the latter beginning the continuous molar series. The second premolar has the crown much compressed, while the third and fourth are triangular in form. The three true molars have the usual crescents corresponding to those above, but no inner cingulum.

The Cranium of the Female.

The type-species of the genus *Protoceras*, as already stated, was the skull of a female, and it may be well to repeat here its essential features as given in the original description already cited. In Fig. 2 below, most of the main characters of this type-specimen are represented.

"In general form and proportions, this skull is of the ruminant type. Its most striking feature is a pair of small horn-cores, situated, not on the frontals, but on the parietals, immediately behind the frontal suture. These prominences were thus placed directly over the cerebral hemispheres of the brain.

"The frontal bones are very rugose on their upper surface, and this rugosity extends backward on the parietals, and to the summit of the horn-cores, as well as between the latter, and along the wide sagittal crest. The horn-cores are well separated from each other, and point upward, outward, and backward, overhanging somewhat the temporal fossæ. They are conical in form, with obtuse summits.

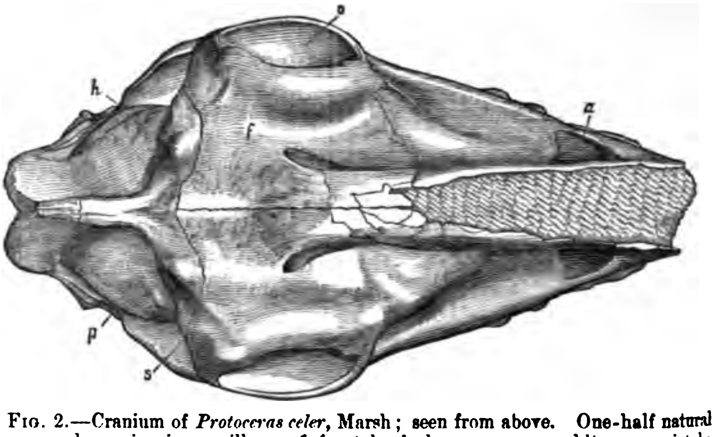

FIG. 2.—Cranium of *Protoceras celer*, Marsh; seen from above. One-half natural size. *a*, depression in maxillary; *f*, frontal; *h*, horn-core; *o*, orbit; *p*, parietal; *s*, suture between frontal and parietal. Miocene: South Dakota.

"Between the orbits, the frontals are depressed, and marked by two deep grooves leading backward to the supra-orbital foramina. Behind these, half-way to the horn-cores, is a median prominence resembling in shape the corresponding elevation on the skull of the male giraffe. The brain cavity is unusually large for a Miocene mammal. The occiput is very narrow, indicating a small cerebellum, and the occipital crest is weak. The occipital surface slopes backward.

"The facial region of the skull is narrow and elongate. On the outer surface of the maxillary, just above the antorbital foramen, there is a deep depression, which probably contained a gland. The usual ruminant fossa in front of the orbit appears to be wanting. The orbit is large, and completely closed behind by a strong bar of bone.

"The dentition preserved is selenodont and brachyodont, with only three premolars and three molars.[1] The first premolar is much compressed transversely, and has but a slight inner lobe. The second premolar is triangular in outline, the inner lobe being much more developed. The last premolar has this lobe expanded into a strong cusp, and the crown thus becomes broader than long. The true molars have two inner cusps, each with a basal ridge. The outer crescents have a median vertical ridge. The enamel of the molar series is more or less rugose. There was a wide diastema in front of the premolars.

"The posterior nares are situated far forward, the anterior border being opposite to the posterior cusp of the second true molar. The glenoid facet is large and convex, but the postglenoid process is quite small. The paroccipital processes were well developed, but there were apparently no auditory bullæ."

A number of other female skulls, some of them in excellent preservation, have since been obtained from the same region in which the type was found, and a study of these makes clear the main points of their structure. It is not quite certain to which of the three species of *Protoceras* now known some of these skulls should be referred, but further investigation will doubtless determine this point, as the present material in the Yale Museum is apparently sufficient for this purpose.

All the known remains of *Protoceras* are from the Upper Miocene of South Dakota. The horizon, which is a definite one, has been appropriately called by Dr. Wortman the *Protoceras* beds. They appear to be identical with the series in Oregon, which the writer had previously named the *Miohippus* beds, as that genus and several others are common to both regions.

EXPLANATION OF PLATE XIX.

Skull of the male of *Protoceras celer*, Marsh; oblique side view. Three-fourths natural size. Miocene: South Dakota, U.S.A.

II.—William Smith's Manuscript Maps.

By Professor J. W. Judd, C.B., LL.D., F.R.S., F.G.S., etc.

It is well known to all students of the history of geology that, although the date of publication of William Smith's "Map of the Strata of England and Wales" was the year 1815, yet even before the commencement of the present century the "Father of English Geology" had not only established the principle that strata can be identified by their organic remains, but had actually applied that important principle in the construction of a number of geological sections and maps. Conclusive documentary evidence of the truth of this statement is fortunately in the possession of the Geological Society. The way in which these important documents were acquired by the Society is well known to all geologists. When the Wollaston Medal was founded, it was unanimously resolved by the Council of the Geological Society (January 11, 1831)—

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[1] More perfect specimens since discovered prove that there were four premolars, the first being absent in the type.

"That the first Wollaston Medal be given to Mr. William Smith, in consideration of his being a great original discoverer in English Geology; and especially for his having been the first, in this country, to discover and to teach the identification of strata, and to determine their succession by means of their imbedded fossils."

To the lucid historical statement in which the President of the Society—Professor Adam Sedgwick—explained and justified this award, William Smith replied in "a short and manly speech," which he concluded by presenting to the Society "some documents referred to in the President's address." These documents were as follows:—

1. A table of the Order of Strata, and their imbedded Organic Remains, in the vicinity of Bath; examined and proved prior to 1799.
2. A map of the country five miles round Bath, on the scale of one and a half inches to the mile. "Coloured geologically in 1799, by William Smith."
3. The first draft of a geological map of England and Wales, entitled "General Map of Strata found in England and Wales, by William Smith, surveyor, 1801."

The careful reader of the historical statements drawn up by Fitton,[1] Sedgwick,[2] and Phillips,[3] will be satisfied that other and still earlier documentary evidence, in the form of manuscript sections and maps, once existed, and had been examined by those authors. But it is highly probable that by the year 1831 all such manuscripts, which could be regarded as important pieces of evidence, had been given away or lost by William Smith, with the exception of the three presented by him to the Geological Society. At all events, I fear that the chance of the recovery of any such manuscripts of William Smith, is now a remote one. Twenty-five years ago, the late Mr. W. Stephen Mitchell set himself the task of hunting for relics of the Father of English Geology in Bath and elsewhere. I was at the time in frequent communication with Mr. Mitchell, who was able to take counsel with John Phillips and other contemporaries of William Smith, then living and able to direct him in his inquiries; but I gathered that these investigations were fruitless, and that though many biographical details of interest were collected by Mr. Mitchell, yet that no fresh manuscripts of Smith were found to reward his labours.

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[1] The Edinburgh Review, February, 1818; the London and Edinburgh Philosophical Magazine, vol. i, pp. 147-60, 268-75, 442-50; and vol. ii, pp. 37-57, (1832-3).

[2] Proceedings of the Geological Society (1831), pp. 270-80.

[3] Memoirs of William Smith, Author of "The Map of the Strata of England and Wales," 1844.

This being the case, the three documents in the possession of the Geological Society must be regarded of the very highest importance and of priceless value. They have been mounted on linen and framed, and have never left the custody of the officers of the Geological Society, except in the year 1876, when they were exhibited for some months at the Loan Collection of Scientific Apparatus in the South Kensington Museum.

As it appeared to me that this valuable evidence of the early work of William Smith ought to be made more accessible to the general public, while it is manifestly desirable that the precious originals themselves should never leave the custody of the Society, or be subjected to the smallest risk of loss or injury, I sought some time ago (on behalf of the Department of Science and Art) the permission of the Council of the Geological Society to have facsimile copies made of these important documents, for exhibition in the Science Museum at South Kensington, among the illustrations of British and Foreign Geological Maps.

This permission having been generously granted to me, I have taken the opportunity of making a careful and critical examination of the documents, the age and value of which are substantiated by such eminently satisfactory external and internal evidence.

It is obvious from an inspection of these manuscripts, that they have been many times folded and unfolded, and probably carried in a pocket or pocket-book, and that at the time they were mounted they were in a state of extreme dilapidation. Unfortunately, as is now only too evident, the manuscripts, after being pasted on linen mounts, were covered with a coating of varnish, which was very unevenly applied. This varnish, which has turned perfectly yellow with age, renders it very difficult to get good photographic reproductions of the documents, or to be quite certain, in some cases, as to the nature and distribution of the colours upon them. The removal of the varnish would have been attended with risk to the water-coloured maps; I therefore had to be satisfied with the best reproductions that could be obtained by the skilled photographer of the Department of Science and Art, and these were carefully coloured, after the originals, by Miss Margaret Reeks, under my superintendence. In the choice of colours we were guided to some extent by the later published maps and sections of William Smith, for it is evident that in many of his methods he was very conservative. It is hoped that these facsimiles, though they are not so good as could have been made from manuscripts in a less permanently discoloured condition, show all the important features of the documents as they originally left the hands of their author.

Four sets of these facsimile reproductions have been prepared. One set is exhibited in the rooms devoted to Geology and Mineralogy in the Science Museum at South Kensington; a second set is placed in the Library of the Geological Society; a third goes to the

Geological Department of the Natural History Museum at Cromwell Road, South Kensington; and a fourth to the Library of the British Museum at Bloomsbury.

The origin of the first of the three documents of the series has been admirably told by Phillips in his "Life of Smith" (p. 29).

"One day, after dining together at the house of the Rev. Joseph Townsend" (29, Pulteney Street, Bath), "it was proposed by one of this triumvirate" (Smith, Richardson, and Townsend) "that a tabular view of the main features of the subject, as it had been expounded by Mr. Smith, and verified and enriched by their joint labours, should be drawn up in writing. Richardson held the pen and wrote down, from Smith's dictation, the different strata according to their order of succession in descending order, commencing with the Chalk, and numbered, in continuous series, down to the Coal, below which the strata were not sufficiently determined. To this description of the strata was added, in the proper places, a list of the most remarkable fossils which had been gathered in the several layers of rock. The names of these fossils were principally supplied by Mr. Richardson, and are such as were then, and for a long time afterwards, familiarly employed in many collections near Bath. Of the document thus jointly arranged, each person present took a copy,[1] under no stipulation as to the use which should be made of it, and accordingly it was extensively distributed, and remained for a long period the type and authority for the descriptions and order of superposition of the strata near Bath."

The table in the possession of the Geological Society is in the handwriting of Richardson, but bears the following attestation written by Smith himself:

"This table of the strata, dictated by myself, is in the handwriting of the Rev. Benjamin Richardson, and was first reduced to writing at the house of the Rev. Joseph Townsend, Pulteney Street, Bath, 1799.—Wm. Smith."

"This very curious and important document," as Sedgwick pointed out, "was the first tabular sketch of our formations, drawn up before William Smith had, in conjunction with Mr. Richardson, finally decided upon the names by which they ought to be designated; and the successive groups, from the Coal-measures to the Chalk inclusive, are represented by a series of numbers, accompanied with explanatory notes, but without any proper names affixed to them."[2]

As full transcripts of this table have been published by both Fitton[3] and Phillips,[4] it will be sufficient here to indicate the several divisions then recognized by Smith with the names by which they were subsequently known.

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[1] According to a written statement of William Smith, published by Fitton, a copy of the document was, at the time it was drawn up, given to William James, Esq.

[2] Proc. Geol. Soc., vol. i (1831), p. 276.

[3] Phil. Mag., vol. ii (1833), pp. 46, 47.

[4] "Life of Wlliam Smith," p. 30.

1. Chalk, 300 feet (Chalk, Upper and Lower).
2. Sand, 70 feet (Firestone, Upper Greensand).
3. Clay, 30 feet (Gault).
4. Sand and Stone, 30 feet (Portlandian or Cornbrash ?).
5. Clay, 15 feet (Bradford Clay ?).
6. Forest Marble, 10 feet (Forest Marble).
7. Freestone, 60 feet (Great or Bath Oolite).
8. Blue Clay, 6 feet
9. Yellow Clay, 8 feet
10. Fuller's Earth, 6 feet } Fuller's Earth Series.
11. Bastard ditto and sundries
12. Freestone, 30 feet (Inferior Oolite).
13. Sand, 30 feet (Midford Sand).
14. Marle Blue, 40 feet } Lias.
15. Lias Blue, 25 feet
16. Lias White, 15 feet } Rhætic.
17. Marlestone Indigo and Black Marle, 15 feet
18. Red-ground, 180 feet (Trias).
19. Milstone
20. Pennant Stone
21. Grays } Carboniferous.
22. Cliff
23. Coal

The absence of distinctive names to the strata, with the inadequate thicknesses assigned to some of them, and some minor errors as to the order of succession, afford sufficient evidence, if this were needed, that the document is really of the early date which it bears.

The second document in this series is even more interesting, as it may be justly regarded as the oldest *geological* map in existence, if we distinguish geological from agricultural or soil maps. We cannot do better than tell its history in Smith's own words—

"During my five years' close confinement" (1794–99) "to practical engineering on the Coal Canal, my much-wished-for opportunity of collecting observations enough from the ranges of the different strata to make an accurate delineation of the stratification throughout England were suspended."

But after his connection with the Coal-Canal works had ceased, Smith adds—

"I drew in colours, on a map of the vicinity of Bath and on Day and Masters' County Survey, all very accurately to a certain extent, which embraced an interesting but intricate variety of strata in hills around Bath."[1]

The geologically coloured copy of Day and Masters' Map of Somersetshire (on the scale of one inch to a mile) was publicly exhibited and explained by Smith at an annual Agricultural Meeting at Bath in the year 1799. This map unfortunately has been lost, but the Map of the Vicinity of Bath is one of the documents preserved by the Geological Society. It bears the inscription in Smith's handwriting:

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[1] Phillips' "Life of William Smith," p. 27.

"Presented to the Geological Society, Feb. 18th, 1831.
Wm. Smith.
Coloured Geologically in 1799."

The basis of this geological map is of circular form and 15 inches in diameter. It is entitled: "A Map of Five Miles round the City of Bath, on a scale of one inch and a half to a mile, from an Actual Survey, including all the New Roads, with Alterations and Improvements to the present time, 1799." "Printed for and sold by A. Taylor and W. Moyler, Booksellers, Bath."

Although this map includes only a very small area, it presents many features of great interest. In the first place, it shows that William Smith was aware of the importance of representing upon maps the actual limits between the outcrops of different strata. Though no lines are drawn, Smith's well-known method of colouring the base of a formation with a deep tint, and shading this upwards towards the outcrop of the next overlying stratum, enables us to see how carefully he had mapped all the geological lines around Bath. There are only three colours employed on the map and no index; but it is evident that the yellow tint represents the Bath Oolite, the base of the freestones being very accurately mapped, so that even the smallest outliers can be made out agreeing most closely with the map of the Geological Survey; a blue tint is drawn at the base of the Lias, and a red one at the base of the Trias, the inliers of Carboniferous being left blank. How far William Smith was in advance of his contemporaries, is shown by a comparison of this map of William Smith, showing carefully indicated lines of outcrop, with the excellent map of the Environs of Paris by Cuvier and Brongniart (1809), in which colour is spread over the areas occupied by the several formations, without any clear and definite indications of the actual limits of the outcrops. The colours used by Smith in this map were the same as those employed by him in the later maps of 1801 and 1815, and thus we have in it the first indication of a scheme of colour now very generally adopted by geologists.

The third and most important of these documents is a copy of Carey's Index to the Map of England, coloured geologically. The map is eleven inches high by nine inches in breadth, and has the manuscript title, "General Map of Strata found in England and Wales, by Wm. Smith, Surveyor, 1801." On the side of the map is written, "Wm. Smith, Milford, near Bath," and at the bottom, "Presented to the Geological Society by Wm. Smith, Feb. 21, 1831," all the inscriptions being in Smith's own handwriting.

Before considering the geological information which is furnished by this map, it will be interesting to recall the opportunities which Smith really had of making himself acquainted with the positions of the outcrops of the English strata. When between 12 and 13 years of age (in 1781), Smith paid a visit to London, and appears have been greatly struck by an exposure of the Chalk in a road- ting at Henley. In 1787, when 18 years of age, he was)renticed to Edward Webb, and, as he himself says, "was ployed in the survey of estates and the inclosure of extensive nmons and open fields in the counties of Oxford, Warwick,)rcester, Gloucester, Wilts, Hants, and Somerset, which embraced the strata, from the red marl at Inkborough and Rugby, near ;ester, to the sand and gravel over chalk at Dibden, between the w Forest and Southampton."

When Smith settled in Somersetshire in 1791, he was familiar th "the surface of the country from London to Bath, and from ırwick to Southampton"; and during his surveys at Stowey and High Littleton Collieries (1791–2) he not only found fresh dence of his views about the superposition and continuity of the eral strata, but detected the unconformity between the Secondary ata and the underlying Carboniferous rocks. In 1793, while :ing levels for the Somersetshire Coal Canal, he "proved the red rl, lias, blue marl, and inferior oolite on the tops of the highest ls to be generally inclined towards the east; and this notion of general declination appeared to hold through all the varieties of ata in the considerable extent of country before noticed; and er levels down two parallel valleys in the same strata seemed ther to confirm the same notion." In 1794 Smith made a post- ıise journey of 900 miles—from Bath to Newcastle-on-Tyne by route, and back again by another—and was able to satisfy nself that the order of succession which he had made out in the ıth-west of England could be applied to the whole of the country. ring the period that Smith was resident engineer to the Somerset- re Coal Canal (1793–9), he not only worked out the minute ails of the order of succession of the Jurassic rocks in the district, t finding difficulty in identifying the several Jurassic strata—owing the resemblances between the several clays and oolitic limestones different geological horizons—he was led to the great discovery th which his name will ever be associated. In Smith's own rds: "Doubts were at length removed by a more particular ention to the site of the organized fossils, which I had long lected. This discovery of a mode of identifying the strata by organized fossils respectively imbedded therein—the sharpness those in their primitive sites, contrasted with the same fossils ınded and water-worn in gravel—led to the most important dis- ctions, which at once seemed to clear away the rubbish and nmon stumbling-blocks in geology."

It will thus be seen that at the date when Smith prepared the ınuscript geological map of England, he had minutely surveyed Jurassic strata and Carboniferous rocks of Somersetshire, and ned a wide but much more general knowledge of all the strata, m the Chalk to the Coal-measures inclusive, over an area :ending from Warwickshire and the Bristol Channel on the west London and Southampton on the east. Outside this area, Smith's ɔwledge of the country was derived from his post-chaise journey to the north, supplemented by persevering inquiries in every quarter where he could hope to glean information.

The idea of a general geological map of England appears to have been generated in the mind of William Smith upon the occasion of the famous post-chaise journey in 1794; but during his five years' close confinement to practical engineering on the Coal Canal, his much-wished-for opportunities of collecting observations enough from the ranges of the different strata to make an accurate delineation of the stratification throughout England were, as we have already seen, suspended.

The leisure which followed his resignation of the post of Resident Engineer to the Coal Canal was spent by Smith in endeavouring to carry out his great scheme. He says that he "wasted much time in poring over maps, in contriving how the ranging edges and planes of the different strata could best be rendered intelligible; models were thought of, and one small map was cut along the edges of some of the strata with a view of defining their extent, and of showing how one stratum was successively covered by another." He adds that "some small maps of England were spoiled by speculating on the ranges of stratification without sufficient data. The intricacies in their marginal edges were such that I found, to mark point by point, as the facts were ascertained, was the only way in which I could safely proceed."

The result of Smith's speculations as to the best way of representing the outcropping strata upon maps is seen in the method which he finally adopted, and which was first illustrated in the manuscript maps of 1799 and 1801. The *base* of each formation is shown by a band of colour which is shaded upwards towards the next succeeding formation. The colours adopted in the manuscript geological map of England and Wales of 1801 appear to have been very similar to those used in Smith's later engraved maps.

There is nothing in the way of an index of colours attached to this first geological map of England and Wales, but, by reference to the author's later publications, it is not difficult to determine what the several bands of colour are intended to indicate. The formations of which the outcrops are represented range from the Chalk to the Old Red Sandstone, the colours employed being eight in number, though a number of other signs, indicating collieries, mines, and slate-quarries, adds much to the valuable information supplied by this remarkable map.

The strata represented are, in descending order, as follows:—

1. Chalk (*green*).
2. "Sand of the Portland Rock," with which is confounded (as in later maps) the Carstone of Norfolk (*purple*).
3. Oxford Clay ("Church Clay" of Smith) (*grey*).
4. Oolite. The outcrop represented is that of the Great Oolite of the Bath area, and of the Inferior Oolite both south and north of that area (*yellow*).
5. Lias (*dull blue*).
6. Trias and Permian ("Red Marl" of Smith) (*light red*).

7. Carboniferous Limestone, with which is confounded the Magnesian Limestone (*bright blue*).
8. Old Red Sandstone (*reddish-brown*).

The distribution of the Coal-measures is indicated by the crowding together of the crosses representing collieries; the position of the slaty rocks by marks standing for slate-quarries; while a few mines are represented in the North of England, Wales, and Derbyshire, but none in Cornwall!

The east coast of Great Britain has been roughly continued by a manuscript line as far as Forfarshire, the name "Redhead" being written nearly in the position of Arbroath. Collieries are represented near Edinburgh, a colliery and limestone, with the words "Coal 9 yards thick," in the South of Fife, and limestone in Forfarshire. Where the west coast of Scotland would appear we have in Smith's handwriting "Slate, etc., Eysdale Island, Isle of Bute." In the Isle of Man patches of colour indicate the limestones of Castletown and the red sandstones of Peel.

While this first sketch of a geological map is remarkable for the accuracy with which the main outlines of the geological structure of the country are represented, certain omissions and errors are noteworthy as affording the clearest evidence that the map was actually constructed at the date written upon it (1801), and that it had no additions made to it at a later date.

The absence of any colouring for the Tertiary strata of East Anglia and the London and Hampshire Basins, for the Wealden area, and for the Jurassic district of the Eastern Moorlands of Yorkshire, are especially striking in this connection. It can be shown that in the years immediately following 1801, Smith had opportunities, which he utilized with more or less success, in obtaining information concerning these three districts, but no trace of knowledge concerning them appears on the map. Yet of his industry and ingenuity in bringing together every fact which could aid him in the construction of the map of 1801 we have abundant proofs. The Yorkshire Wolds were only seen by him from the top of York Minster and recognized by their contour, yet the range of the Chalk is well represented in Yorkshire and Lincolnshire, as well as in the North and South Downs, and in Dorsetshire and the Isle of Wight. Accurate information was obtained by Smith, as we have seen, concerning Scotland and the Isle of Man, which he had never visited, and it may be added, as further evidence of his painstaking inquiries, that a colliery is represented at Bovey Tracey and another in the Eastern Moorlands of Yorkshire.

Alike, then, from its excellence and its defects, this map appeals to British Geologists as being the first sketch—an imperfect one it is true, but far in advance of any earlier or contemporary work—of that remarkable "Map of the Strata of England and Wales" which was published by William Smith in 1815, and which will ever remain the most striking monument of his genius.

III.—On some Rock-Specimens from Kimberley, South Africa.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

A PAPER on the diamantiferous rock of Kimberley by Sir J. B. Stone, M.P., Miss Raisin, and myself, was published in this Magazine in 1895.[1] Since then the first-named has received from friends in South Africa another parcel of specimens, obtained, at a greater depth than heretofore, in the De Beers mine. These specimens, twenty in number, he kindly entrusted to me for description. They represent, as will be seen, not only the diamantiferous breccia, but also the associated igneous and sedimentary rocks. Two specimens among the first-named appeared to be in very good preservation; the others were more or less decomposed, though much more solid than the material which was brought to England in the earlier days of the industry. About the same time I had the opportunity of examining a fine collection of the minerals and rocks which had been obtained by Sir W. Crookes, F.R.S.,[2] during a recent visit to Kimberley. One specimen of diamantiferous breccia among these appeared to me in better preservation than even that which formed the principal subject of our former paper, so he kindly permitted me to have a piece removed for microscopic examination, and a description of it is included in this paper. During the present year the investigations of the Kimberley rock left in manuscript by the late Professor Carvill Lewis have been published,[3] which give a much more elaborate account of its mineral constituents than has hitherto appeared. This enables me to pass rapidly over the mineralogical part of the subject, and to restrict myself to a few details which seem to me of some little petrological interest. The method of working the mines, by sinking vertical shafts outside the area of the "pipe" and driving from them horizontal levels at intervals, is now so well known as to render needless any explanation of the terms employed. I group the specimens, for purposes of description, under three heads: (1) the diamantiferous breccia, (2) the dykes and other igneous rocks, (3) the associated sedimentary rocks.

1. *The Diamantiferous Breccia.*

Of this there are seven specimens, but slices have been cut from three only, for the others, as was proved by a single trial, were not sufficiently well preserved to give useful results. These three proved to be in excellent condition.

Four specimens come from the 1,200-feet level. They are rather irregular in shape, and their volumes probably lie between 15 and 20 cubic inches.[4] They are numbered and labelled as follows:

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[1] Geological Magazine, 1895, pp. 492, 496.

[2] Reference to these is made in "The Genesis and Matrix of the Diamond," by the late Professor H. Carvill Lewis, p. 69.

[3] "Papers and Notes on the Genesis and Matrix of the Diamond," 1897 (Longmans).

[4] I mention the size here and elsewhere in order to show that my conclusion as to the origin of the rock is not founded on small specimens, which in the case of so variable a rock as the breccia is of some importance.

No. 11, Soft Blue, East"; "No. 12, Hard Blue"; "No. 13, West-le Blue"; "No. 14, Soft Blue." All look rather decomposed,). 13 being, perhaps, in the best condition. The olivine grains are :pentinized or still more decomposed. Brown mica is generally esent, but is not abundant; here and there a grain of iron-oxide ıy be seen, and in one or two a garnet. No. 11 contains several unded fragments of a compact dull-green rock, with a slight zonal 'ucture near to and symmetrical with the exterior. The largest, iich is subangular in shape, measuring about 1" in length and ¾" breadth, has been examined microscopically, and will be described er on. No. 12 contains a fair number of small fragments of shale, iich have a rather indurated aspect. The block also includes part a mass of calcite, with a dull-green border. The greatest length this mass, the exact nature of which I cannot determine, is nost 1½". No. 13 also contains numerous fragments, very variable size. Of these a considerable proportion, some angular, some ip-like, represent a blackish shale, the largest specimen being about in length. In No. 14 small chips of shale are rather numerous.

A slice was cut from (13), since this seemed the more promising the four specimens, but it could not be made sufficiently thin give any information of value. The larger olivine grains are idently much serpentinized. The rock fragments appear to be ıard carbonaceous shale, but to these I shall return.

One specimen, that belonging to Sir W. Crookes, comes from the 320-feet level, being marked "No. 22 level, north, Hard-blue." ıis fragment is slightly pyramidal in shape, the base measuring out 4½" × 3½", the greatest height being about 4". The s.g. is '83.[1] The ground-mass is rather compact, in colour blackish-ey, with a purplish tinge. Enclosures are numerous, varying ıch in size and nature. Of the minerals, olivine is abundant in ains of very variable size, which frequently seem to have escaped 'pentinization. Brown mica, garnets, and iron-oxide are also ible, the first being the commonest. Rock fragments are fairly merous, the most abundant being subangular in outline, dark dull-een in colour, with a lighter border; they are rather serpentinous aspect, and have a hardness about 3. Some of the smaller are tinctly redder in colour than the rest. Two or three fragments, luding the largest (about ¾" × ⅜") are more of a grey-green in lour (with a lighter margin), and have a more "speckled" ect, but they do not materially differ in hardness. Time will be ved by describing together the microscopic structure of this and next two specimens. These (in Sir J. B. Stone's collection), m the 1,400-feet level, are distinguished on the labels as "15, st Blue" and "16, West Blue."

In (15), a fragment (? with a slight indication of parallel joint mes) approximately 4" × 3" × 1¼", the ground-mass resembles ıt in the specimen last described. Grains and fragments are ttered about it, but rather more sparsely than usual, and they seldom exceed ¼" in diameter, the largest, a flake of brown mica, being barely ½". A few of them represent the compact darkish rock with a lighter border, already mentioned; the rest are minerals, most of these being olivine, more or less serpentinized; two or three are brown mica, one or two grains are garnet and iron-oxide—all as usual. The s.g. of the rock is 2·695.

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[1] The specific gravities were determined by a Walker's balance. In this and eral other matters I have to thank Miss C. A. Raisin, B.Sc., for kind help.

The other fragment (16) is rudely wedge-shaped, the most regular side being about 4" square. The ground-mass is as above, but the purplish tinge is more variable. Enclosures are fairly numerous, but seldom exceed ⅓" in diameter, the largest (olivine, or possibly a peridotite) being about ½". Olivine, more or less serpentinized, is very abundant in grains markedly variable in size. Other minerals are inconspicuous. There are a few rock fragments, most of them representing the usual compact darkish kind, but the largest one resembles a fine-grained eclogite. The s.g. of the rock is 2·658.

Slices for microscopic examination have been prepared from the specimen from the 1320-feet level and the two from 1400-feet. The first shows a number of fragments, both of mineral and of rock, scattered in a ground-mass; they are more or less rounded, especially the former, which are the more numerous, though here and there the sharp edge of a fracture can be seen. In size they vary from about ·16" downwards, though larger are present. The minerals are: olivine, enstatite, augite, brown mica, and perofskite. The first and second are partially serpentinized, often only as an external zone, but occasionally to a considerable extent, and a small grain may be entirely changed.[1] In size these olivine grains often vary from about ·0125" to ·006", but smaller than the latter may be found, and it is difficult to say where the fragments stop. There are only a few grains of the brownish mica, with the usual external zone. Grains of perofskite are numerous, varying in colour and size; some certainly are of secondary origin, and it is possible that all may be.[2] Small black grains also occur, sometimes associated with these, probably magnetite or ilmenite. The rock fragments, which are very interesting, I leave for the moment. The ground-mass seems to consist of about three minerals, besides grains of opacite and ferrite—(1) a rather flaky mineral, the tints of which, with crossed nicols, do not rise above a dull lead-white; (2) numerous, generally well-defined, flakes, in length up to about ·005", a very pale-brown tint to colourless, with bright polarization colours—a mica[3]; (3) an irregularly outlined clear granular mineral giving bright tints, probably dolomite.

The specimen from the 1400-feet level labelled "East Blue" includes mineral and rock fragments, as usual, the largest (rock) being rather more than 3″ in diameter. Among the former, except for one small grain of brown mica, I can only identify with certainty olivine, which shows varying amounts of serpentinization. The matrix differs only in one respect from that last described, and from its usual character in this rock—that it has a more pronounced brown tint, due to the abundance of a rather minute mica, as described above, which sometimes appears almost to form a "setting" for the other minerals. The second specimen, labelled "West Blue," departs in two directions from the normal type: (*a*) the mineral fragments almost all consist of a greenish-yellow serpentine; (*b*) the matrix generally exhibits a distinct warm-brown tint, due to the occurrence of a mica in numerous small rectangular plates. This mica, with a magnification of about 80 linear, is seen to be more definite and regular in outline, richer in colour, and more abundant than in the last-named or in any other specimen that I have examined. In one or two places we find associated with it sporadic clusters of a small prismatic mineral, about ·005″ in length, which is practically colourless, affords high polarization tints, and extinguishes at angles ranging up to about 40°. This mineral, which I think we may identify as an augite, is included in both the mica and the serpentine. The latter mineral, in the matrix or in small enclosures, sometimes exhibits a tendency to spherulitic structure. All, I think, must be of secondary origin, and the aspect of the mica leads me to suspect slight contact metamorphism, such as might be produced by a dyke.

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[1] For the structures of the serpentine and the olivine, see Lewis, ut supra, p. 14.

[2] In our former paper we separated the dark-coloured varieties as possibly pseudobrookite, because we thought sundry slight differences, not only dependent on size, were perceptible. But study of these slices and of Professor Lewis's description makes me doubt whether the latter specimens are more than impure perofskite, so I follow him in placing all under the one name.

[3] A true white mica may be present among them, but in most cases a faint yellowish tint with a trace of pleochroism is perceptible. I think this mineral must be authigenous.

We come next to the rock fragments. A few are holocrystalline; the rest are sedimentary.[1] The former are represented in (*a*) by the following: one which contains parts of two grains of olivine (this, however, might possibly be a compound porphyritic crystal rather than a bit of a peridotite); another which consists of two flakes of brown mica, with an interstitial mineral, probably calcite; a third which is formed of a piece of a garnet, with a border of kelephite (on the outer side only),[2] and of a colourless augite. This, no doubt, represents the rock containing red garnet and green pyroxene[3] which was described from larger fragments by Miss Raisin and myself.[4] Among the fragments more or less certainly of sedimentary origin, the commonest type, subangular in shape, consists of a compact, rather dark-purplish rock, with a pale greenish-grey border, sometimes banded; but the tints exhibit minor variations, small fragments sometimes having their inner part of a paler and redder colour with a more jaspery aspect. The microscopic structure similarly varies. The outer zone commonly exhibits a slight brownish tint, which darkens towards the inner side. With a magnification of about 80 diameters, this is seen to be crowded with small prisms which give low polarization tints and oblique extinction. These towards the outer part are more thinly scattered, are about five times as long as wide and a little ragged at the ends, and are pale greenish or brownish with rather bright polarization tints and extinction angles high enough for augite. The almost colourless base, in which these and some yet smaller microliths are scattered, seems generally to be isotropic, but here and there small aggregates occur of some feebly double-refracting mineral. The interior of another fragment in (*a*) is more varied: it contains several ragged flakes of a brown mica, somewhat bigger than the prisms. Also minute grains of a clear mineral, with a high refraction index. Their form suggests an isometric mineral, but they afford bright tints with crossed nicols. Thirdly, a fair number of roundish grains of larger size, colourless, but giving faint indications of a flaky structure, with no visible effect on polarized light. The exterior of a fragment in (*b*) shows a considerable amount of a very pale-brown mica, and prisms or flakes of a colourless mineral, extinguishing as hornblende rather than augite. The interior is granular in structure, ferrite-stained, with numerous black specks variable in size and some flakelets of brown mica.[1] It has a fragmental aspect, and may contain some bits of decomposed felspar. In another fragment the narrow outer part is blackened with opacite, though a clear ground-mass, like serpentine, may be distinguished, but the interior is much stained with ferrite. High magnification, however, reveals a fair amount of brown mica and a few black spots (? graphite). The small rock fragments in all the specimens show a general correspondence with the outer zone only of the larger, consisting of flakes or prisms of mica, pyroxene, etc., in a clear ground-mass, resembling a serpentine, but possibly a pseudophite. A subrotund fragment in (11)—the 1200-feet level, East—about 1″ in longer diameter, having the usual purplish-brown interior and a banded greenish-grey outer zone, which is quite $\frac{1}{8}$″ wide, has also been examined. The structure does not essentially differ from some of those described above, except that there is practically no suggestion of contact metamorphism. The interior resembles a mudstone, probably rather carbonaceous, and containing a few flakelets of a colourless mica. The outer zone does not materially differ from the interior, except that it has a rather more clotted aspect, and shows brown lines roughly concentric with the exterior, probably indicating old cracks. In this zone an infiltration of a colourless serpentinous mineral is perceptible, which also occasionally (together with some streaks of a chloritic mineral) fills an interval between the matrix and the fragments, and occupies one or two cracks in the interior.

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[1] For purpose of reference we may denote the specimen from the three places mentioned above as *a*, *b*, *c*, respectively.

[2] This obviously must have been formed after the fragment was imbedded in the breccia.

[3] The chrome diopside of Professor Carvill Lewis, op. cit., p. 21.

[4] GEOL. MAG. 1891, p. 412.

These specimens of the diamantiferous breccia have afforded me better opportunities of studying included fragments of sedimentary rock than those described in 1895. I believe them to represent ordinary shales or argillites, which have undergone two forms of alteration. The first, not sufficient to change materially the general character of the rock, is probably due to heat; i.e., is a form of contact metamorphism and in most cases is comparatively slight. I have not been able to identify any representatives of a glassy or of a minutely crystalline peridotite, and now, after better opportunities of studying rock fragments than on any former occasion, I feel more doubtful than before whether these really occur. The second alteration—that which has produced the external zoning—I attribute to the action of water, possibly at a fairly high temperature, and probably containing in solution some constituents which it obtained during its passage through the surrounding rock.[1]

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[1] Minute perofskite may be present in this fragment.

The difficulty of ascertaining the true nature of this diamantiferous rock mainly arises from the secondary changes which its matrix has undergone; the principal being infiltration with carbonates and serpentinization. It occurred to me that this might be partially avoided by another method of examination. In the first instance, a small fragment of matrix from Sir W. Crookes' specimen was pulverized, no more force being used than was absolutely necessary. The material, after being kept in HCl, in one case for perhaps a quarter of an hour, in another for two days (no difference seemed to result), was mounted for microscopic examination. Mineral grains are fairly abundant; mostly olivine, with a very few of augite and mica. Their outlines are distinctly those of fragments, not of crystals. This, of course, might be attributed to the force used in breaking up the rock, but as the matrix is barely half as hard as olivine, and great care was taken, I think it improbable that crystals of this mineral would have been much shattered. However, in order to get rid of this difficulty, some other chips from the same specimen and some bits of ordinary soft blue ground (given to me several years ago by Professor Boyd Dawkins) were immersed in HCl (50 per cent.). Though the acid was changed and the tubes were frequently shaken, not much powder was detached even at the end of about five months,[2] but the mineral grains in this are identical in shape with those obtained by the other mode of examination. This has materially strengthened my conviction that the "Kimberlite" is in reality a rock of fragmental origin.

(*To be continued.*)

IV.—SIR HENRY H. HOWORTH AND THE GLACIATION OF NORWAY.

By Prof. EDWARD HULL, M.A., LL.D., F.R.S., F.G.S.

FEW will deny that whatever comes from the pen of Sir Henry Howorth is always interesting and original, whether the reader agrees with it or otherwise. This is especially the case when he has a theory to build up or to overturn, and in the latter case he not only tries to knock over his antagonist, but he discharges at him volleys of brilliant verbiage with the view to his utter annihilation. On no former occasion has this been exemplified more fully than in his essay on "The Surface Contour of Scandinavia and Finland" in the GEOLOGICAL MAGAZINE for August last, p. 355. In this he has, as he himself says, undertaken "the hazardous work" of overthrowing the Glacial theory as applied to Scandinavia in the face of the evidence which has served to convince the great majority of observers, of the highest eminence and competency, of which amongst those living Professor James Geikie may be considered the chief exponent. In such a case Sir H. Howorth is another *Athanasius contra mundum*. Under the influence of his *perfervidum ingenium* and facile rhetoric the North Sea ice-sheet dissolves, and if it does not become the baseless fabric of a vision, is left as "a very ricketty cripple." Can any state be more deplorable! Glacialists have all been deceived. The North Sea never was packed with ice, stretching to the British shores, and the mammillated rock-surfaces—their parallel grooves and striæ—are deceptions practised by that sad mimic Dame Nature to entrap credulous geologists, who ought to have known that such phenomena are due to "the continued beating, and wearing, and washing of the rocky surfaces of a rising land, assisted possibly in part by shore-ice, and the movement of ice hummocks and gravel, etc."[1] So it all goes for nothing that similarly mammillated and striated surfaces have been observed by numerous naturalists, from Agassiz, Charpentier, and James Forbes downwards, lining the valleys of the Alps, Caucasus, Himalayas, aye, and of Scandinavia itself; for it appears, according to our author, that the inference regarding the mode of formation applied to these is inapplicable in the case of the rocky coasts of Norway. *There* ice has been the sculptor; *here* it has been wave-action and the rest, with "shore-ice" thrown in: but where are we to draw the line?

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[1] I now think it more likely than when I wrote the preface to Professor Lewis' papers, that this has given a serpentinous aspect to certain small fragments which I then conceived might represent a compact or glassy peridotite.

[2] The pieces left are still too hard to crush between finger and thumb. This seems to indicate that calcite or dolomite is not the only cement of the rock.

Such views, coming from so respected a source, filled me with amazement. It required several perusals to make it certain that I myself was not the victim of a hallucination. I had persuaded myself that if any deduction in theoretical geology had been placed upon an unassailable basis it was that of a Scandinavian ice-sheet, which had filled the North Sea and impinged upon our coast. If such were not the case, and the North Sea ice is only a "very ricketty cripple," will Sir H. Howorth explain the remarkable deflection which the glacial *striæ* undergo when traced towards the eastern coast from the interior Highlands and Uplands of Scotland? What other agency than that of *a mer de glace* blocking the seaward path could have caused the old glacier-ice to change its course to the right hand and to the left, and to traverse the Orkneys and Shetlands in a north-westerly direction? Surely not the unresisting waters of an open sea, even if studded with some floating ice! Perhaps this is a problem which may not have presented itself to the mind of the author of the essay; but, unless he can furnish a sufficient explanation differing from that here suggested, his whole argument falls to the ground.[1]

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[1] Page 356.

When we come to inquire what may be the grounds on which Sir H. Howorth has been compelled to dissent from views which have been advanced and illustrated by numerous writers, we find that they are based on the striking evidences of submergence and subsequent emergence which abound around the coasts of Scandinavia and adjoining regions, in which we may include the British Isles; for the Post-Pliocene phenomena of both are similar in kind, if not in degree. These are so obtrusive and overwhelming that they leave no room in the author's mind for the equally striking evidences of extensive glaciation. But the phenomena resulting from both conditions lie side by side; yet are they sufficiently distinct to demand distinct explanation. As regards the proofs of submergence and subsequent elevation we are fully agreed. Some of the evidences adduced by the author, gathered from Credner, regarding the marine forms still surviving in the Swedish, Norwegian, and Finnish lakes, are of extreme interest and importance. These evidences of former Scandinavian submergence to the extent of 600 to 800 feet, based on unquestionable data, are especially opportune, since there are some British geologists who do not admit the evidences of similar subsidence in the case of their own country; but it would have been strange indeed, if not incredible, that Scandinavia could have been depressed to so great an extent while the British Isles remained stationary. Passing, therefore, from the question of subsidence and re-elevation, we have only to deal with that of former elevation and glaciation. On this point, Sir H. Howorth says (p. 360): "They [namely, the champions of the Glacial theory] claim further that before the land was covered by the sea it stood at a probably much higher level than it even does now, and was consequently capable of nursing a great ice-sheet. Of direct evidence of this former higher level of the land, I know none whatever."

In the first place I may observe that direct evidence, such as can be afforded by the glaciated rock-surfaces, can only be followed down to the low-water line, and so far it is clear enough. The polished and striated surfaces may be traced downwards so far; but is there any warrant for supposing that they cease at this line? Nay, is it not more probable that they accompany the surfaces which form the sea-bord down to considerably greater depths? In any case, it is equally open to contend that this is the case, as is the contrary.

But it is here necessary to deny in the most positive terms that the glaciated rock-surfaces which we find lining the coasts and islands, scored and grooved in parallel lines over extensive tracts, can be due to wave or current action. Such action would not result in grooving the rocks in rectilinear directions at right angles, or oblique, to the coastline, but sometimes even parallel thereto. As a matter of fact, however, as far as my observation goes (and I have visited a considerable extent of shore-line in all parts of the British Isles and elsewhere) the sea never does sculpture rock-surfaces in the same manner as does glacier-ice, either past or present. Ice-action on rocks is *sui generis*, and sea-action, when opportunity offers, only tends to obliterate, not to produce, the sculptured surfaces.

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[1] The course of the ice movement over the same region is shown on Professor James Geikie's glacial map of Scotland, and on one of the general glaciation of the British Isles in the writer's "Physical History of the British Isles" (p. 118, pl. xiii). Also: Croll, "Climate and Time," p. 444; Peach and Horne, Quart. Journ. Geol. Soc., vol. xxxvi, p. 648; T. F. Jamieson, ibid., vol. xxii, p. 261.

But notwithstanding our author's statement, there really does exist direct evidence of the former higher level at which the Scandinavian region, including the British Isles, once stood; evidence to which the late Mr. Godwin-Austen was (if I recollect aright) the first to call attention, and which was afterwards more fully worked out by Professor T. Rupert Jones; I refer to the submerged river system of the North Sea plateau. It is well known from soundings that the British Isles and the Scandinavian promontory are planted on a platform of an average depth of 100 fathoms, beyond which the descent is rapid to deeper levels. This platform is known to be traversed by channels continuous with some of the existing larger rivers, which converge towards a main channel, just like tributaries to a large river, and this channel, pursuing a northerly direction, opens out into the Atlantic at the edge of the plateau.[1] There can be no doubt but that these channels were originally those of a river system at a time when the North Sea, or German Ocean, was a land-surface, and stood at least 600 or 700 feet higher than at present, how much higher we cannot tell. But it is worthy of notice, that the extent of the elevation corresponds very closely with that of the depression which may be inferred in the cases of Scandinavia and the British Isles from the levels of shell-bearing beds, amounting altogether to a combined rise and fall of 1,200 to 1,400 feet.

Here, then, is the "direct evidence" of which my distinguished friend stands in need; I do not doubt that he will give it, as also the glacial deflections of Scotland, due consideration.

It now remains to show that the phenomena of submergence and glaciation are not incompatible with each other. The author appears to me to have commenced his historical essay on the Glacial period at Chapter II. The introductory Chapter I, which would deal with elevation and glaciation, he has strangely overlooked. True, that towards the close of this part of his essay he shows by the passage already quoted, that he has had an inkling of an epoch anterior to that of submersion. Let him give the introductory chapter in the history of the Glacial period fair consideration, and then he will see how well it fits in with that epoch to which his mind has been so forcibly directed. It is many years since I held the views for which,

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[1] In the paper on "Another possible Cause of the Glacial Epoch," to which the Council of the Geological Society thought proper to refuse publication, I adduced the case of this submerged plateau as being a representative of those of the eastern coast of America and the Antilles so ably worked out by Professor Spencer.

I believe, I am primarily indebted to Lyell; views which I taught to my class in Dublin, and which time has only tended to confirm; namely, that the Great Ice Age was introduced by a general rise of the land bordering the North Atlantic, accompanied by increased cold and Glacial conditions, followed by submergence and inter-Glacial, or milder, conditions of temperature; this again, by emergence and elevation ultimately attaining to the present levels, including minor marginal undulations. These were the three great physical epochs of the Glacial period. When firmly grasped, they are the wards of a key which serves to unlock the many difficulties in the phenomena of the Post-Pliocene period. If Sir Henry Howorth will condescend to make use of this key he will probably find a solution to his difficulties as regards the views of his opponents, while fresh light will be thrown on those he so ably expounds. He will see how it explains the superimposition of marine stratified deposits on glaciated rock-surfaces and *moraine-profonde* matter-deposits, differing in age and in conditions of formation. I am writing these notes at a distance from books, maps, and memoirs, which I hope will be accepted as my apology for errors, whether of omission or commission.

NOTICES OF MEMOIRS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

TORONTO, AUGUST 18TH, 1897.

PRESIDENTIAL ADDRESS

By Sir JOHN EVANS, K.C.B., D.C.L., LL.D., Sc.D., V.P.S.A., For. Sec. G.S., etc.

THE President said the British Association, for a second time, had the honour and pleasure of accepting the hospitality of Canada. On their last visit in 1884, their place of assembly was Montreal, a city which is justly proud of her M'Gill University; to-day they met within the buildings of another of the Universities of the vast Dominion, and in a city the absolute fitness of which for such a purpose must have been foreseen by the native Indian tribes when they gave to a small aggregation of huts upon that spot the name of Toronto—"the place of meetings." His election to the important post he now held might, in the main, be regarded as a recognition by this Association of the value of Archæology as a science. It was no doubt hard to define the exact limits to be assigned to Archæology as a science, and Archæology as a branch of history and *belles lettres*. A distinction did, however, exist between Archæology proper and what, for want of a better word, might be termed Antiquarianism.

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A familiarity with all the details of Greek and Roman mythology and culture must be regarded as a literary rather than a scientific qualification; and yet, when among the records of classical times they came upon traces of manners and customs which had survived for generations, and which seemed to throw some rays of light upon the dim past, when history and writing were unknown, they were approaching the boundaries of scientific Archæology.

Every reader of Virgil knew that the Greeks were not merely orators, but that with a pair of compasses they could describe the movements of the heavens and fix the rising of the stars; but when by modern Astronomy we could determine the heliacal rising of some well-known star, with which the worship in some given ancient temple was known to have been connected, and could fix its position on the horizon at some particular spot, say, three thousand years ago, and then found that the axis of the temple was directed exactly towards that spot, we had some trustworthy scientific evidence that the temple in question must have been erected at a date approximately 1100 years B.C. If on or close to the same site we found that more than one temple was erected, each having a different orientation, these variations, following as they might fairly be presumed to do, the changing position of the rising of the dominant star, would also afford a guide as to the chronological order of the different foundations. The researches of Mr. Penrose seemed to show that in certain Greek temples, of which the date of foundation was known from history, the actual orientation corresponded with that theoretically deduced from astronomical data.

Sir J. Norman Lockyer had shown that what holds good for Greek temples applied to many of far earlier date in Egypt, though up to the present time hardly a sufficient number of accurate observations had been made to justify us in foreseeing all the instructive results that might be expected to arise from Astronomy coming to the aid of Archæology.

The intimate connection of Archæology with other sciences was in no case so evident as with respect to Geology.

By the application of geological methods many archæological questions relating even to subjects on the borders of the historical period had been satisfactorily solved.

When they came to the consideration of the relics of the Early Iron and Bronze Ages, the aid of chemistry had of necessity to be invoked. By its means they were able to determine whether the iron of a tool or weapon was of meteoritic or volcanic origin, or had been reduced from iron-ore, in which case considerable knowledge of metallurgy would be involved on the part of those who made it. With bronze antiquities the nature and extent of the alloys combined with the copper might throw light not only on their chronological position, but on the sources whence the copper, tin, and other metals of which they consisted were originally derived.

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Like Chemistry, Mineralogy and Petrology might be called to the assistance of Archæology in determining the nature and source of the rocks of which ancient stone implements were made; and, thanks to researches of the followers of those sciences, the old view that all such implements formed of jade and found in Europe must of necessity have been fashioned from material imported from Asia could no longer be maintained. In one respect the Archæologist differed in opinion from the Mineralogist, namely, as to the propriety of chipping off fragments from perfect and highly-finished specimens for the purpose of submitting them to microscopic examination.

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When they came to discuss that remote age in which were found the earliest traces at present known of man's appearance upon earth, the aid of Geology and Palæontology became absolutely imperative.

The changes in the surface configuration and in the extent of the land, especially in a country like Britain, as well as the modifications of the fauna and flora since those days, had been such that the archæologist pure and simple was incompetent to deal with them, and he must either himself undertake the study of these other sciences or call experts in them to his assistance. The evidence that man had already appeared upon the earth was afforded by stone implements wrought by his hands, and it fell strictly within the province of the archæologist to judge whether given specimens were so wrought or not; it rested with the geologist to determine their stratigraphical or chronological position, while the palæontologist could pronounce upon the age and character of the associated fauna and flora.

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Of late years the general tendency of those engaged upon the question of the antiquity of the human race had been in the direction of seeking for evidence by which the existence of Man upon the earth could be carried back to a date earlier than that of the Quaternary gravels.

There is little doubt that such evidence would eventually be forthcoming, but, judging from all probability, it was not in Northern Europe that the cradle of the human race would eventually be discovered, but in some part of the world more favoured by a tropical climate, where abundant means of subsistence could be procured, and where the necessity for warm clothing did not exist.

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With Palæolithic man, we were treading on comparatively secure ground, and the discoveries of the last forty years in Britain alone enabled us to a great extent to reconstitute his history. We might not know the exact geological period when first he settled in the British area, but we had good evidence that he occupied it at a time when the configuration of the surface was entirely different from what it is at present; when the river valleys had not been cut down to anything like their existing depth, when the fauna of the country was of a totally different character from that of the present day, when the extension of the southern part of the island seaward was in places such that the land was continuous with that of the continent, and when in all probability a far

more rainy climate prevailed. We had proofs of
of the country by man during the long lapse of
necessary for the excavation of the river valleys.
the old floors on which his habitations were fixed, w
to trace him at work on the manufacture of flint i
by building up, the one upon the other, the flake
the primæval workmen in those remote times we
to reconstruct the blocks of flint which served as his

That the duration of the Palæolithic Period must
over an almost incredible length of time, was suf
by the fact that valleys, some miles in width and of
100 to 150 feet, had been eroded since the deposi
implement-bearing beds. Nor was the apparent
period diminished by the consideration that th
hollowed out the valleys were not in all probability
occurrence as to teach Palæolithic man by experie
of settling so near to the streams, for had he kep
slopes of the valley there would have been but litt
implements having so constantly formed constitue
gravels deposited by the floods.

The examination of British cave-deposits as at
Torquay, afforded corroborative evidence of this ex
of the Palæolithic Period.

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In a cavern at Creswell Crags, on the confines
and Nottinghamshire, a bone had been found
a representation of parts of a horse in precisely
as the engraved bones of the French caves.

It was uncertain whether any of the river-
belonged to so late a date as these artistic caver
the greatly superior antiquity of even these to any
was testified by the thick layer of stalagmite,
deposited in Kent's Cavern before its occupation
Neolithic and Bronze Periods.

Towards the close of the period covered by the h
of the French caves, there seemed to have been
the number of the larger animals constituting
fauna, whereas their remains were present in ab
lower and therefore more recent of the valley
circumstance might afford an argument in favour
period represented by the later French caves as
of that during which the old river gravels were
yet the great change in the fauna that had tak
the latest of the cave-deposits included in the Palæoli
indicative of an immense lapse of time.

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We found distinct traces of river-action from
above the level of existing streams and rivers,
at a great distance from them; we observed old fres
on the slopes of valleys several miles in width;

long and lofty escarpments of rock had receded unknown distances since their summits were first occupied by Palæolithic man; we saw that the whole side of a wide river valley had been carried away by an invasion of the sea, which attacked and removed a barrier of chalk cliffs from 400 to 600 feet in height; we found what was formerly an inland river had been widened out into an arm of the sea, now the highway of our fleets, and that gravels which were originally deposited in the bed of some ancient river now capped isolated and lofty hills.

And yet, remote as the date of the first known occupation of Britain by man might be, it belonged to what, geologically speaking, must be regarded as a quite recent period, for we were now in a position to fix with some degree of accuracy its place on the geological scale. Thanks to the investigations ably carried out at Hoxne in Suffolk, and at Hitchin in Hertfordshire, by Mr. Clement Reid, under the auspices of that Association and of the Royal Society, we knew that the implement-bearing beds at those places undoubtedly belonged to a time subsequent to the deposit of the Great Chalky Boulder-clay of the Eastern counties of England. It was, of course, self-evident that this vast deposit, in whatever manner it might have been formed, could not, for centuries after its deposition was complete, have presented a surface inhabitable by man. Moreover, at a distance but little farther north, beds existed which also, though at a somewhat later date, were apparently formed under glacial conditions. At Hoxne the interval between the deposit of the Boulder-clay and of the implement-bearing beds was distinctly proved to have witnessed at least two noteworthy changes in climate. The beds immediately reposing on the clay were characterized by the presence of alder in abundance, of hazel, and yew, as well as by that of numerous flowering plants indicative of a temperate climate very different from that under which the Boulder-clay itself was formed. Above these beds, characterized by temperate plants, came a thick and more recent series of strata, in which leaves of the dwarf Arctic willow and birch abounded, and which were in all probability deposited under conditions like those of the cold regions of Siberia and North America.

At a higher level, and of more recent date than these—from which they were entirely distinct—were the beds containing Palæolithic implements, formed in all probability under conditions not essentially different from those of the present day. However this might be, we had now conclusive evidence that the Palæolithic implements were, in the Eastern counties of England, of a date long posterior to that of the Great Chalky Boulder-clay.

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It must not, however, for a moment be supposed that there were the slightest grounds for believing that the civilization, such as it was, of the Palæolithic period originated in the British Isles. We found in other countries implements so identical in form and character with British specimens that they might have been

manufactured by the same hands. These occurred over large areas in France under similar conditions to those that prevailed in England. The same forms had been discovered in the ancient river gravels of Italy, Spain, and Portugal. Some few had been recorded from the North of Africa, and analogous types occurred in considerable numbers in the south of that continent. On the banks of the Nile, many hundreds of feet above its present level, implements of the European types had been discovered; while in Somali-land, in an ancient river valley at a great elevation above the sea, Mr. Seton-Karr had collected a large number of implements formed of flint and quartzite, which, judging from their form and character, might have been dug out of the drift deposits of the Somme or the Seine, the Thames or the ancient Solent.

In the valley of the Euphrates implements of the same kind had also been found, and again farther east in the Lateritic deposits of Southern India they have been obtained in considerable numbers.

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Was this not a case in which the imagination might be fairly invoked in aid of science? Might we not from these data attempt in some degree to build up and reconstruct the early history of the human family? There, in Eastern Asia, in a tropical climate, with the means of subsistence readily at hand, might we not picture to ourselves our earliest ancestors gradually developing from a lowly origin, acquiring a taste for hunting, if not indeed being driven to protect themselves from the beasts around them, and evolving the more complicated forms of tools or weapons from the simpler flakes which had previously served them as knives? Might we not imagine that, when once the stage of civilization denoted by these Palæolithic implements had been reached, the game for the hunter became scarcer, and that his life in consequence assumed a more nomad character? Then, and possibly not till then, might a series of migrations to "fresh woods and pastures new" not unnaturally have ensued, and these following the usual course of "westward towards the setting sun" might eventually lead to a Palæolithic population finding its way to the extreme borders of Western Europe, where we found such numerous traces of its presence.

How long a term of years might be involved in such a migration it was impossible to say, but that such a migration took place the phenomena seemed to justify us in believing.

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As yet, our records of discoveries in India and Eastern Asia were but scanty; but it was there that the traces of the cradle of the human race were, in his opinion, to be sought, and possibly future discoveries might place upon a more solid foundation the visionary structure he had ventured to erect.

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It might be worth while to carry their speculations rather further, and to consider the relations in time between the Palæolithic and the Neolithic Periods.

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At the close of the period during which the valleys were being eroded came that represented by the latest occupation of the caves by Palæolithic man, when, both in Britain and in the south of France, the reindeer was abundant; but, among the stone weapons and implements of that long troglodytic phase of man's history, not a single example with the edge sharpened by grinding had as yet been found. All that could safely be said was that the larger implements, as well as the larger mammals, had become scarcer, that greater power in chipping flint had been attained, that the arts of the engraver and the sculptor had considerably developed, and that the use of the bow had probably been discovered.

Directly they encountered the relics of the Neolithic Period, often, in the case of the caves lately mentioned, separated from the earlier remains by a thick layer of underlying stalagmite, they found flint hatchets polished at the edge and on the surface, cutting at the broad and not at the narrow end, and other forms of implements associated with a fauna in all essential respects identical with that of the present day.

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So far as he knew we had as yet no trustworthy evidence of any transition from the one age to the other, and the gulf between them remained practically unbridged. We could, indeed, hardly name the part of the world in which to seek the cradle of Neolithic civilization, though we know that traces of what appeared to have been a stone-using people had been discovered in Egypt, and that what must be among the latest of the relics of their industry had been assigned to a date some 3,500 to 4,000 years before our era. The men of that time had attained to the highest degree of skill in working flint that had ever been reached. Their beautifully-made knives and spear-heads seemed indicative of a culminating point reached after long ages of experience; but whence these artists in flint came or who they were was at present absolutely unknown, and their handiworks afforded no clue to help us in tracing their origin.

Taking a wider survey, we might say that, generally speaking, not only the fauna but the surface configuration of the country were, in Western Europe at all events, much the same at the commencement of the Neolithic Period as they are at the present day. We had, too, no geological indications to aid us in forming any chronological scale.

. . . .

But, pending the advent of evidence to the contrary, we might provisionally adopt the view that owing to failure of food, climatal changes, or other causes, the occupation of Western Europe by Palæolithic man absolutely ceased, and that it was not until after an interval of long duration that Europe was repeopled by a race of men immigrating from some other part of the globe where the human race had survived, and in course of ages had developed a higher stage of culture than that of the Palæolithic man.

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Returning to the realms of fact, one fact on which he desired to insist was that of the existence at the present day, in close juxtaposition with our own civilization, of races of men who, at all events but a few generations ago, lived under much the same conditions as did our own Neolithic predecessors in Europe.

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The manners and customs of these primitive tribes and peoples were changing day by day, their languages were becoming obsolete, their myths and traditions were dying out, their ancient processes of manufacture were falling into oblivion, and their numbers were rapidly diminishing, so that it seemed inevitable that ere long many of these interesting populations would become absolutely extinct. The admirable Bureau of Ethnology instituted in the United States of America had done much towards preserving a knowledge of the various native races on that vast Continent; and in Canada the annual Archæological Reports presented to the Minister of Education were rendering good service in the same cause.

Moreover, the Committee of the British Association appointed to investigate the physical characters, languages, and industrial and social conditions of the North-Western tribes of the Dominion of Canada was about to present its twelfth and final report, which, in conjunction with those already presented, would do much towards preserving a knowledge of the habits and languages of those tribes.

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It was, however, lamentable to notice how little was being or had been officially done towards preserving a full record of the habits, beliefs, arts, myths, languages, and physical characteristics of the countless other tribes and nations, more or less uncivilized, which were comprised within the limits of the British Empire. At the meeting of this Association held last year in Liverpool it was resolved by the General Committee to press upon the Government the necessity of establishing a Bureau of Ethnology for Greater Britain. Wherever such a bureau was to be established, in connection with the British Museum or the Imperial Institute . . . . the question of its existence must of necessity rest with Her Majesty's Government and Treasury, inasmuch as without funds, however moderate, the undertaking could not be carried on. He trusted that, in considering the question, it would always be borne in mind that in the relations between civilized and uncivilized nations and races it was of the first importance that the prejudices, and especially the religious or semi-religious and caste prejudices, of the latter should be thoroughly well known to the former. If but a single "little war" could be avoided in consequence of the knowledge acquired and stored up by the Bureau of Ethnology preventing such a misunderstanding as might culminate in warfare, the cost of such an institution would quickly be saved.

It might be thought that he should have taken that opportunity to discuss some more general subject, such as the advances made in the various departments of science since last the Association met in Canada. These topics would, however, be discussed by more competent authorities in the various Sections of the Association by means of the Presidential addresses or otherwise. He occupied his position as a representative of Archæology, and was, therefore, justified in bringing before them a subject in which every member of every race of mankind ought to be interested—the antiquity of the human family and the scenes of its infancy.

Others would direct their thoughts in other directions, but the farther they proceeded the more clearly would they realize the connection and interdependence of all departments of science. Year after year, as meetings of this Association took place, they might foresee that "many shall run to and fro and knowledge shall be increased." Year after year advances would be made in science; and in reading that Book of Nature which was ever open before their eyes, successive stones would be brought for building up that Temple of Knowledge of which their fathers and they had laboured to lay the foundations.

II.—British Association for the Advancement of Science. Sixty-Seventh Annual Meeting, held at Toronto, Canada, August 18–25, 1897.

List of Papers read in Section C, Geology.

Dr. G. M. Dawson, C.M.G., F.R.S., F.G.S., President.

President's Address.—On the Pre-Cambrian Rocks of Canada.

Dr. F. D. Adams.—On the Structure and Origin of certain Rocks of the Laurentian System.

Dr. R. W. Ells.—Problems in Quebec Geology.

Dr. L. W. Bailey.—Some Typical Sections in South-Western Nova Scotia.

Dr. E. W. Claypole.—Palæozoic Geography of the Eastern States.

J. C. Branner.—The Former Extension of the Appalachians across Mississippi, Louisiana, and Texas.

Dr. F. D. Adams and *J. T. Nicholson.*—Preliminary Notice of some Experiments on the Flow of Rocks.

Professor W. J. Sollas, F.R.S.—Report of the Committee for the Investigation of a Coral Reef.

E. J. Garwood.—Report of the Committee on Life-Zones in the British Carboniferous Rocks.

R. T. Hill.—The Stratigraphic Succession in Jamaica.

Professor T. C. Chamberlin.—A Group of Hypotheses bearing on Climatic Changes.

Professor T. C. Chamberlin.—Distribution and Succession of the Pleistocene Ice-Sheets of the Northern United States.

Professor A. Penck.—The Glacial Deposits of the Alps.

Prince Kropotkin.—On the Asar of Finland.

H. B. Woodward, F.R.S.—The Chalky Boulder-Clay and the Glacial Phenomena of the Western-Midland Counties of England.

Professor A. P. Coleman.—Glacial and Interglacial Deposits at Toronto.

Dr. J. W Spencer.—On the Continental Elevation of the Glacial Epoch.

F. B. Taylor.—The Champlain Submergence and Uplift, and their Relations to the Great Lakes and Niagara Falls.

G. K. Gilbert.—Remarks introductory to the Excursion to Niagara Falls and Gorge.

Bailey Willis.—Drift Phenomena of Puget Sound and their Interpretation.

Professor C. H. Hitchcock.—The Southern Lobe of the Laurentian Ice-Sheet.

Professor N. S. Shaler.—On the Origin of Drumlins.

R. Chalmers.—The Pre-Glacial Decay of Rocks in Eastern Canada.

Sir William Dawson, F.R.S.—Note on certain Pre-Cambrian and Cambrian Fossils supposed to be related to Eozoon.

A. C. Seward, M.A. — On the Possible Identity of *Bennettites*, *Williamsonia*, and *Zamites gigas*.

J. F. Whiteaves.—Note on a Dendrodont Fish-tooth from Silurian Rocks of Nova Scotia.

H. M. Ami, D.Sc.—On some new or hitherto little known Palæozoic Formations in North-Eastern America.

Dr. G. F. Matthew.—Some Characteristic Genera of the Cambrian.

Professor T. Rupert Jones, F.R.S.—Report of the Committee on the Fossil Phyllopoda of the Palæozoic Rocks.

J. Milne and *A. J. Jukes-Browne.*—Report of the Committee on the Secondary Fossils of Moreseat, Aberdeenshire.

M. l'Abbé J. C K. Laflamme.—Influence d'un éboulement sur le régime d'une Rivière.

Captain S. G. McDakin.—Report of the Coast Erosion Committee of the East Kent and Dover Natural History Societies.

H. N. Ridley.—Report of the Committee on the Fauna of Caves near Singapore.

P. F. Kendall.—Report of the Committee on the Erratic Blocks of the British Islands.

A. E. Barlow, M.A., and *W. F. Ferrier, B.Sc.* — On the Relations and Structure of certain Granites and associated Arkoses on Lake Temiscaming, Canada.

P. M. C. Kermode.—Report of the Committee on the Irish Elk Remains in the Isle of Man.

Professor W. G. Miller.—On some Nickeliferous Magnetites.

J. J. H. Teall, F.R.S.—Differentiation in Igneous Magmas as a result of Progressive Crystallization.

J. B. Tyrrell, B.Sc.—The Glaciation of North-Central Canada.

Dr. E. Gilpin, Jun.—The Geological Horizon of some Nova Scotia Minerals.

W. F. Ferrier, B.Sc.—The Minerals of the Elæolite-syenite near Montreal.

W. L. Goodwin and *Professor W. G. Miller.* — Some Economic Minerals of Ontario.

Professor H. Le Roy Fairchild.—Glacial Geology of Western New York.

Professor J. Milne, F.R.S.—Second Report on Seismological Investigation.
O. H. Howarth.—Earth Strains and Structure.
Professor W. W. Watts.—Report of the Committee for Collecting Photographs of Geological Interest.
Dr. Otto Hahn.—Exhibit of Photographs and Sections of Meteorites.

Papers bearing upon Geology and Palæontology read in other Sections, namely :

Section A.—Mathematical and Physical Science.

Lord Kelvin.—On the Fuel-Supply and Air-Supply of the World.

Section B.—Chemistry.

F. T. Shutt.—The Composition of Canadian Virgin Soils.
Professor W. H. Ellis.—Analyses of some Pre-Carboniferous Coals.
Report of the Committee to inquire into the Proximate Chemical Constituents of the various kinds of Coal.

Section D.—Zoology.

Professor H. F. Osborn.—On a Restoration of *Phenacodus primævus.*
Professor H. F. Osborn.—On Skeletons and Restorations of Tertiary Mammalia.
J. F. Whiteaves.—On new Sepiadæ from the Lower Cretaceous of the South Saskatchewan.
Professor C. S. Minot.—The Origin of Vertebrata.
Professor H. F. Osborn.—The Origin of Mammalia.

Section E.—Geography.

J. B. Tyrrell.—The Barren Lands of Canada.
Charles D. Walcott.—The Geographical Work of the United States Geological Survey.
J. White.—The Geographical Work of the Canadian Geological Survey.

Section H.—Anthropology.

Joint Discussion with Section C, Geology.—*Subject* : "The First Traces of Man in the New World."
  Professor F. W. Putnam.—The Trenton Gravels.
  Professor E. W. Claypole.—Human Relics in the Drift of Ohio.
The President.—Exhibition of Lance-headed Implements of Glass from North-West Australia.
F. H. Cushing.—The Genesis of Implement-Making.
Professor A. C. Haddon.—Adze-Making in the Andaman Islands.

Section K.—Botany.

A. C. Seward.—Lecture on Fossil Plants.
A. C. Seward.—Notes on Fossil Equisetaceæ.

REVIEWS.

I.—On the Origin of the European Fauna. By R. F. Scharff, Ph.D., B.Sc., F.Z.S., Keeper of the Natural History Collections in the Dublin Museum of Science and Art. Proc. Roy. Irish Acad., 3rd ser., vol. iv, No. 3, 1897, pp. 427–514. 8vo. (Dublin, 1897.)

(*Continued from the September Number, page* 427.)

PURSUING his inquiry into the origin of the European Fauna, Dr. Scharff advocates, with the Russian Naturalist Tcherski, a mild climate in Pleistocene times for Northern Asia.

The Climate of Siberia and Northern Russia during the Glacial Period.—"We have to choose between one of two alternatives—either Northern Russia was covered by a mass of ice, and then Siberia must have been practically uninhabitable, or the climate of both Europe and Siberia were more temperate than it is now. In the face of the numerous works which have been written in recent years by Professor J. Geikie, Professor Penck, Mr. Falsan, Professor Bonney, and many other distinguished geologists, on the proofs of a cold and even Arctic climate in Europe during the Glacial period, it may seem futile to doubt what is put forward as a well-established fact. But with Tcherski I have been led to conclude that Siberia had a comparatively mild climate in Pleistocene times. Northern Europe could not, that being the case, have been glaciated in the manner above described. Before following the migrations of the Siberian fauna to Europe, I must therefore dwell for a little while on the origin of the Continental Boulder-clay." (p. 457.)

Origin of the Boulder-clay.—"I think that I shall be able to advance some additional evidence in favour of the view that the Boulder-clay of Europe is a marine deposit, and that Northern Russia and Germany were not covered by glaciers during the Pliocene or Pleistocene epochs.

"It has been urged by many writers, both on zoological and geological grounds, that at some time during the Pleistocene epoch, or perhaps even later, the White Sea and the Baltic were joined across Northern Russia, and that then also the lowlands of Northern Germany and those of Sweden and Norway were partially flooded. The zoological evidence alone, that such a junction has taken place within recent geological times, is very strong indeed." (p. 458.)

"The assumption that the Arctic mollusca were admitted from the Atlantic to the German Ocean before the deposition of the Lower Boulder-clay, and then found their way into the Baltic, is altogether unwarranted. It is extremely probable that Scotland was connected with Scandinavia till a much more recent period. It is likely, therefore, that a marine transgression from the White Sea took place at the time when the Aralo-Caspian extended much further north than its present boundaries, that the Arctic mollusca migrated from the Arctic Ocean direct to the Baltic, where the Pre-Glacial deposits exhibit a curious intermingling of the ancient southern fauna with the newer immigrants from the north.

"Deposits containing Arctic marine mollusca were also discovered below the Boulder-clay near the shores of the White Sea, another proof of the former extension of the Arctic Ocean in this direction."

Former Land-connection between Scandinavia and North Greenland.—"I can only allude at present to an important feature in the physical geography of Northern Europe, viz., the former continuation of the Scandinavian coastline in a north-westerly direction to Spitzbergen and North Greenland. The cold waters of the Arctic Ocean did not communicate at all with the Atlantic at the time when the above-mentioned changes occurred in Northern Europe, but they poured into the Baltic and the German Ocean, which was then a closed bay, and brought with them the characteristic fauna of the Arctic regions."

The Lowlands of Northern Europe covered by the Sea.—"The Aralo-Caspian communicated with this large northern sea, which had formed on the North European lowlands, and which we may call the "North European Ocean," at a time immediately preceding the deposition of the Upper Boulder-clay. But the barrier which prevented the Siberian fauna from entering Europe was the strait or straits which connected the two seas. We can, therefore, accurately fix the period of the beginning of the migration, for it must have occurred as soon as this barrier disappeared; or, if we are able to ascertain stratigraphically the first appearance of the Siberian immigrants in Central Europe, the disappearance of the barrier must have immediately preceded that period." (p. 462.)

Remains of Siberian Fauna found fossil in England.—"We know that in England remains of Siberian mammals occur from the Forest-bed upward, whilst none are found in older strata. It seems safe to conclude, therefore, that the Siberian migration took place after the deposition of the Lower Continental Boulder-clay, and during or just previous to the formation of the Forest-bed. But the latter has been lately recognized as a Pre-Glacial formation, and it certainly underlies the English Boulder-clay. How can we then reconcile these two apparently very contradictory conclusions—that a migration which undoubtedly set out from the East arrived in Western Europe before it reached Central Europe?

"I have shown in a previous paper that such was certainly the case with some southern Asiatic mammals, which entered Europe from Greece, and migrated along the Mediterranean coast to Northern Africa at a time when a land-bridge still existed between it and Southern Italy, and then recrossed again to Spain, where at last they turned north to appear in Western Europe, without having crossed the central parts of the continent. Such, however, could not possibly have been the course of migration of the Siberian mammals, since they are not found in Southern Europe or in North Africa. Hence one of the two alternatives must be accepted: either some radical mistake has been made in the previous arguments, or the Forest-bed is an Interglacial deposit, and contemporaneous with the 'Loess' formation in which the Siberian animals have been discovered in Northern Germany. I believe in the latter hypothesis. If this view should be correct, the whole of the British Pliocene strata, or a portion of them, must be of the same age as the Lower Continental Boulder-clay. The marine fauna which made its way west from the Arctic Ocean across the North Russian plains, and reappeared again on the Baltic coasts just before the deposition of the Boulder-clay, must have entered the German Ocean and left its traces behind in the strata which formed on the east coast of England. And this is precisely what occurred. 'In the oldest member of the Pliocene system,' remarks Professor J. Geikie 'in the Coralline Crag, the general facies of the fauna clearly indicates a warm, temperate climate, for all the living species are southern forms. In the Red Crag, however, northern forms begin to appear, and increase in numbers as we pass upwards to the higher members, while at the same time the extinct and southern forms gradually die out.' If the view that the Forest-bed represents an Interglacial deposit is correct, as indeed has already been suggested by Professor Geikie, the whole of the newer British Pliocene is synchronous with the Lower Continental Boulder-clay." (p. 463.)

On the Condition of the Old Land-surface in Southern Russia during the Siberian Migration to the West.—"We may assume, therefore, that this tract of land, over which the Siberian fauna wandered, consisted of a vast prairie. On their arrival in the more central parts of Europe, the Siberian mammals spread into Austria, Hungary, and Northern Italy, throughout the greater part of Germany and France, and into England. They scarcely touched any part of Southern Europe, and their progress in France was apparently arrested by the Garonne, as no typical Siberian forms are found fossil south of that river, in the Pyrenees, or in Spain. Of course, more recently the Siberian survivors in Europe have spread not only into Southern Italy and Spain, but also throughout Great Britain and Scandinavia. But none of them entered Ireland, and I have given this as one of my reasons for the belief that this country became separated from England about the time when the Forest-bed was laid down, and has never since been joined to it.

"It is evident that during the deposition of the Forest-bed, the South of England was joined to France. But the two countries must have been united for a considerable time previously, and this is quite in accordance with the opinion expressed by geologists."

The Scandinavian Peninsula.—"As regards the Scandinavian Peninsula, the total absence of mammalian remains in Pleistocene deposits indicates that this country was not connected with the Continent during that period. The presence, on the other hand, of mammalian remains in more recent deposits, chiefly in Southern Sweden, implies that towards the end of the Glacial period, a land-passage must have existed between North-Western Germany and Sweden across Denmark. In referring to the absence of fossil elephants and other large mammals from the Scandinavian Pleistocene strata, Professor Pohlig expresses the belief that Scandinavia must either have been hardly free from ice during the whole of the Glacial period, or, if free from ice during Interglacial times, it could then only have had an imperfect connection with the Continent. That of these alternatives the former was not the case, and if, as I believe, the bulk of the fauna and flora survived the Glacial period in the country itself from Pre-Glacial times, there is no necessity for supposing that any connection existed between the Continent and Scandinavia in Interglacial times." (p. 468.)

The Arctic Migration.—"Three of the Irish mammals, one of which, the reindeer, is now extinct, appear to me to have come direct from the north. Several birds, among the most striking of which may be mentioned the grouse (*Lagopus scoticus*) have formed part of that northern migration. All the Salmonidæ have come to us from the north, whilst a still more noteworthy example of a northern migrant is the stickleback (*Gasterosteus aculeatus*). The land-shells *Helix lamellata* and *Vertigo alpestris*, the beetles *Pelophila borealis, Dytiscus lapponicus, Blethisa multipunctata,* and the moth *Crymodes exulis*, all belong to the same migration. No doubt these and the North American fresh-water sponges, which have been recently discovered on the west coast by the Royal Irish Academy Fauna and Flora Committee, have found their way to Ireland along an old land-connection which formerly united that country with the Arctic regions. In the latter may have originated many of these forms, as well as the plants already referred to, and have migrated to both the Old and the New World. Of course, I have selected only a few of the more prominent examples. As our knowledge of the geographical distribution of the species, which is as yet in its infancy, increases, many other of these northern forms will no doubt be discovered in Ireland."

Arctic Species in Scotland.—"If we cross over to Scotland, we find a very large increase of typically Arctic species of animals and plants; and as these are absent from England, or confined to the Northern counties, there can be no question as to their having migrated direct from the north to Scotland by a former land-passage. It may be urged that these Arctic species have spread over the plain of Europe, have then entered England from the south, and have subsequently been exterminated except in their most northern stations in the British Islands. But whilst we have only very slender geological evidence that such might have been the case; there is, I think, strong evidence for the belief that, until comparatively recent times, Norway and Scotland were joined, so that animals and plants had no need to migrate by that enormously circuitous route by way of Denmark, Holland, Belgium, and England, and across the many large rivers which would have impeded their journey. In Scandinavia, Arctic animals and plants form a large proportion of the fauna and flora, and as we proceed northward, southern forms become more and more scarce. According to Mr. Peterson, no less than thirteen species of Arctic Lepidoptera occur in Northern Europe and North America, but are absent from Asia, and he assumes the probability of a direct land-connection between the two countries by way of Greenland before the Glacial period, and a survival of these in Europe."

Former Land-connection between Greenland, Scandinavia, and the British Islands.—"I think it has been clearly shown that a former land-connection must have existed between Scandinavia and Greenland on the one hand, and between Scandinavia and the British Islands on the other, and that it formed the highway for an extensive migration from the north, and *vice versâ*. Most naturalists, indeed, admit this, but many deny that it could have been anything but Post-Glacial. I believe that the migration took place chiefly in later Pliocene times, i.e. during the deposition of the newer Crags and of the Lower Continental Boulder-clay. The Arctic animals and plants certainly reached the British Islands long before the Siberian immigrants. Throughout the Glacial period (inclusive of the period when the newer Crags were deposited) the White Sea remained connected with the Baltic and the German Ocean, forming the great sea which I ventured to call the North European Sea. Long before the Arctic migration reached the British Islands, another migration advanced from the south; first, as I explained, from South-Western Europe, and, as the climate became colder, from Southern and Central Europe. Many of the animals and plants which arrived with the latter straggled northward into Scandinavia, and even at the present moment they seek to extend their range in a northerly direction. There is no evidence that their progress was checked by the Arctic climate, which is supposed to have prevailed during the Glacial period." (p. 479.)

The Southern Migration.—"The bulk of the Irish fauna and flora belongs to the Southern Migration, and we can divide its members again roughly into those of South-Western and those of Southern or Central European origin. But, in reality, the origin of this migration is an exceedingly complex one, and is all the more difficult to trace as migrations from the south to the north have apparently proceeded uninterruptedly during many of the past geological epochs—certainly during the whole of the Tertiary era. Whilst most of the larger and short-lived forms have died out again, some of the less conspicuous invertebrates are undoubtedly of very ancient origin, and have witnessed vast changes in the fauna and flora surrounding them. Many of these, though their general distribution indicates a southern origin, baffle all attempts at solving the problem of the location of their ancestral home. In some respects the southern migration merges into the Siberian one; for there are a good many English species of animals and plants which, though absent from Ireland, belong certainly to the former. The dormouse (*Muscardinus avellanarius*), for instance, is probably of Central European origin, but it nevertheless is absent from Ireland.[1] Its general range, however, proves that it is of very nt origin, and it has only spread from its original home, which be in the Alps, after Ireland was already disconnected from it Britain. It has never reached Scotland, Spain, Norway, sia, Greece, or any of the Mediterranean islands, except Sicily, re it is present, according to Döederlein. Then there are forms ch, though they have come to the British Islands from Southern ope, have probably not originated there, but in Central or hern Asia. Certain of these Asiatic species have joined what ll this 'Southern Migration,' but subsequently they have ded Europe along with the Siberian Migration. In most of e instances, however, the members of the earlier Southern ration belong to a different variety from those of the later , or exhibit such racial characters, that naturalists are able to nguish them from one another, and thus differentiate between two migrations" (p. 480). The author cites two such cases, ely, those of the European hare and the bullfinch.

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[1] See on this point our criticism in the September number of the GEOL. MAG. on p. 421.

sular Mollusca.—"The mollusca of islands are of great impor- e in studying geographical distribution. A knowledge of the lusca of such islands as Ireland, Sardinia, and Corsica, will help) solve many of the problems associated with their former con- ntal connections. Especially is this the case with the slugs. he sea forms an impassable barrier to slugs, being deadly both emselves and their eggs, the occurrence of the same species on sland and the adjoining mainland proves that these were formerly nected by land."

The great genus *Arion* undoubtedly had its origin in South- tern Europe. Most of the species are still confined to the nish Peninsula; and if we proceed south, east, or north, the nber of species gradually decreases, and outside Europe and thern Africa the genus is quite unknown." (p. 480.)

ange of the Red Deer (*Cervus elaphus*) *and its varieties.*—"The deer as a species has probably reached Ireland from South- tern Europe. Not that I would place its centre of origin in part of the world, for it almost certainly originated in Asia, that geographical conditions at the time of its migrations to ope were such that it had no proper means of spreading over central and northern portions except from that particular on.

In tracing the present range of the red deer, we have to bear nind that there are a number of forms very closely allied to *vus elaphus*, viz., *C. Canadensis*, *C. maral*, *C. Corsicanus*, *arbarus*, *C. Cashmerianus*, *C. affinis*, *C. eustephanus*, and *C. xan- ygus*. Sir Victor Brooke has already referred to the fact that antlers of *C. eustephanus* cannot be distinguished from those *. Canadensis*. A great similarity is said by Professor Nehring cist between many of the antlers found in European Post-Glacial osits and the recent antlers of *C. Canadensis*; and he is inclined efer them, along with the large-antlered Asiatic *C. eustephanus*, *anthopygus*, etc., to the same species, and with this view Pro- or Woldrich agrees. Then, again, *C. maral* is looked upon as a variety of *C. Canadensis*, and identical with *C. eustephanus* and *C. xanthopygus*, by Tcherski; and there can be no doubt as to the specific identity with *C. elaphus* of *C. Corsicanus* and *C. barbarus*.

"It seems altogether probable that all these forms are but races or varieties of the red deer (*C. elaphus*). However, in the shape of the antler, we can separate two groups—one with short and the other with long and powerful ones. The former inhabits Northern Africa, the Mediterranean islands, Ireland, and Western Europe generally, graduating towards the east into the larger form, which occurs in Asia, North America, the Crimea, and in the Caucasus, but is now practically extinct in other parts of Europe." (p. 483.)

Fossil Evidence of the Red Deer.—"I may mention that we have fossil evidence of the great antiquity in Europe of the small race of the red deer. It was found associated in Malta with the pigmy hippopotamus and an extinct elephant, and has been obtained in caves at Gibraltar, in Spain, and in Ireland. All the animals of the southern migration, which I have referred to in the preceding pages, formed part of an exceedingly ancient stream which issued forth from South-Western Europe. As I indicated, they did not all originate there, but the natives of that region were joined by those of Central and Southern Asia, which had wandered to South-Western Europe, across ancient land-connections, by way of Greece, Sicily, and North-West Africa. That the fauna of North-West Africa had come from Europe, and that the latter was not stocked from Africa, has already been maintained by the great palæontologist Rütimeyer and by Bourguignat."

Advance of the Asiatic stream of Southern Migration into Central Europe.—"Owing to the breaking up of old land-connections across the Mediterranean, and to the disappearance of barriers in other places, the Asiatic stream of the southern migration entered Central Europe by a more direct route than before, and was now joined by animals of Central European origin in its northern course. The south-western animals and plants ceased to migrate north, possibly owing to a refrigeration by slow degrees of the climate, and at the present moment many of the members of that early migration, which reached Ireland, have become extinct; most of the survivors, still holding their ground in gradually decreasing numbers, discontinue to spread. The older members of the southern migration are therefore in Ireland more or less confined to the south-western counties. Not only are they there in a climate more in accordance with their original habitat, but what is of more importance, the struggle for existence is less keen there, as comparatively few of the latter immigrants from Southern and Central Europe have penetrated to that part of Ireland. It must be remembered that these changes went on very gradually, step by step. Though the number of the south-western species that migrated north probably grew less as the more eastern forms increased, there can be no doubt that some continued to advance north even after Ireland was separated from England." (p. 485.)

Probable Date of the Separation of Ireland from England.—"If, as I think, it may be taken as an established fact that the south-western branch of the southern migration is the first, and the Siberian migration the last, which reached the British Islands, Ireland must have become disconnected from England during the period intervening between the two. It was, therefore, at the time while the migration from Southern and Central Europe was in progress, that the old land-connection uniting the two countries was severed. That migration, however, did not stop when the Siberian animals invaded Europe. Again, we find the southern forms joining in with those of totally different origin in their wanderings, just as the south-western fauna and flora joined with the Central European. We still have confined to South-Eastern England many of the latest immigrants from Central Europe, such as *Helix pomatia*, *H. carthusiana*, *H. cantiana*, *Buliminus montanus*, and others. A large number of species of plants might be mentioned, and also animals from almost all the groups of terrestrial Invertebrates, which apparently had only reached England before it became disconnected from France, and which are still more or less confined to the south-eastern parts of that country. The majority of these are of Central or South-Eastern European origin.

"Of the Invertebrates we have little or no palæontological proof of the period of their migration to England. But with the Mammals it is very different. We know that the vanguard of the Siberian migration reached England at the time when the Forest-bed was deposited. Every geologist is acquainted also with the fact of the extraordinary mixture of Siberian and southern types of Mammals contained in this bed, as well as in the succeeding Pleistocene ones, and that it has been established beyond a doubt that they must have then lived together, though their original homes often were situated thousands of miles from one another." (p. 486.)

Influence of the Glacial Period on the Climate, and on the Fauna and Flora.—"Whether the destruction of the fauna and flora was caused by ice or water matters little. Almost all British geologists and zoologists are agreed that the bulk of the Irish fauna and flora migrated to Ireland after the Glacial period, because they are somehow or other convinced that it must have been destroyed had it reached the country before that period. I have mentioned before that I do not share these views, and I have shown that the range of species within the British Islands is incompatible with the notion of a repopulation after the Glacial period. 'There are few points,' says Professor J. Geikie, 'we can be more sure of than this, that since the close of the Glacial epoch — since the deposition of the clays with Arctic shells and the *Saxicava* sands— there have been no great oscillations, but only a *gradual amelioration* of climate. It is *quite impossible* to believe that any warm period could have intervened between the last Arctic and the present temperate conditions, without leaving some notable evidence in the superficial deposits of Scotland, Scandinavia, and North America.' In the same way, I think, there are few points we can be more sure of than that the South-Western European fauna and flora in the British Islands are more ancient than the Siberian or the Arctic. If Professor James Geikie were right, it ought certainly to be the other way round. But the evidence as to the climate in the British Islands during the Glacial period is so contradictory, the very nature of that period is so complex, that few scientific subjects during this century have raised more angry discussions, and none have produced a vaster amount of literature. That I should help to increase the latter still more is to be regretted, especially as the subject is not my own, but having been led by faunistic evidence to regard this vexed problem from a side from which it has hitherto received but little attention, I hope I may be excused for venturing to add my own views to those already known." (p. 488.)

The author, after citing the distribution of four species of *Helix*, belonging to the subgenus *Xerophila*, which are spread over almost the whole of Ireland, *except* in the extreme south-west portion, proceeds as follows:—"That the whole Irish fauna and flora could have survived on a now sunken southern extension of Ireland, is, therefore, impossible. They must have remained within the present boundaries of the island during the Glacial period, though it is probable that it did extend somewhat more to the west, south, and north than it does now, and that those parts of the country stood at a relatively higher level to the east; so that the Shannon and some other rivers, which now drain into the Atlantic, emptied their waters into the Irish Sea.

"The nature of the Pleistocene Mammalia of Eastern England is not such as to indicate an Arctic climate in the British Islands. The presence of northern forms is due, as we have seen, to an immigration of Siberian animals; but, as they lived in company with southern types, many of which required an abundance of green food, the winter temperature in the British Islands may have been as high or higher than it is now, though with a lower summer temperature, and with a copious snowfall in winter, glaciers were generated in the mountainous regions. A number of land and fresh-water shells are quoted by Professor J. Geikie from the Arctic fresh-water bed on the coast of Norfolk, in evidence of a rigorous climate. These are spoken of by him as high northern forms; but in this he is mistaken. Every one of them are inhabitants of Ireland at present, and all but one are very common.

"But if the fauna does not indicate Arctic conditions during the Pleistocene epoch in the British Islands, we are told that what is known of the flora, at any rate, is such as to exclude the possibility of its existing under anything but an Arctic climate. The same Arctic fresh-water bed just referred to contains, besides the shells, some plant-remains, and these, according to Mr. C. Reid, imply a lowering of the temperature by about 20° F. Yet the plants of the Forest-bed, Mr. Clement Reid tells us, are not Arctic, and although the land and fresh-water molluscan fauna remains much the same in the later deposits, the plants alone, it appears, are quoted as indicators of temperature." (p. 492.)

"It seems to me probable that the extensive migration of Alpine and Arctic plants, which undoubtedly took place in past ages, did occur long before the Glacial period, during a milder and more equable epoch, and that they have since become adapted to live in countries where they receive sufficient moisture during summer, and are protected from severe frost in the winter by a cover of snow.

"I believe that neither the animals nor the plants which have been discovered in British Pleistocene strata indicate the presence of an Arctic climate in the British Islands during the so-called 'Ice Age.' The theory of a general glaciation of these Islands — the South of England excepted—has, however, been so universally accepted by geologists, that it has almost passed the stage of controversy, and is more generally regarded as an established fact. I am not sure whether even those who are in favour of the view of the marine origin of the Boulder-clay, disbelieve in a previous general glaciation. Yet it is not long ago that the generally accepted view was that all the phenomena now attributed to land-ice had been produced by the action of floating icebergs. The rock-scorings, 'crag and tail,' boulder-clay, scratched stones and drumlins, were all believed to be due to the action of the sea, assisted by floating-ice.

"I will not, however, venture to discuss this extremely intricate subject of land-ice *versus* floating-ice; and hope that geologists may think fit to reconsider their final verdict in the light of the conclusions I have arrived at from a study of the geographical distribution of animals.

"There is one factor of importance in connection with this theory of an ice-sheet which may throw some light on the subject, and that is, the configuration of Ireland during the Glacial period. Mr. Close remarks: 'Some sufficient increase of relative height towards the west or WSW., with a corresponding extension of the land in that direction, is required, if we are to account for the general glaciation of Ireland by the movements of a universal ice-covering formed upon her own surface'; whilst Professor Bonney seems to think that the coast margin in the earlier part of the Glacial period may have roughly corresponded with the present hundred-fathom line. The land-connection between Scandinavia, Scotland, and Ireland, formed, as we have seen, a highway for the migration of the Arctic animals and plants. When the lowlands of Ireland were covered by the sea, which event, I presume, happened some time during the Glacial period, a broad belt of land probably remained separating the Atlantic from this westward extension of the Irish Sea."

Suggested Marine Origin of the Boulder-clay.—"The Boulder-clay, [illegible] covers such vast tracts of country in the British Islands and [illegible]ent, is now generally believed to be the ground-moraine of huge glaciers, but I am inclined to think there is equally strong evidence in favour of its marine origin. Shells of Mollusca and Foraminifera are very frequently present, especially in Ireland, and a remarkable number of species have been identified in that country by Messrs. Praeger and Wright, though the specimens, as a rule, occur in a broken condition. When we consider that the clay in which the shells lived has probably been subjected to considerable movements, it is not surprising that they should be in a fragmentary condition, and that shore forms should often be found mixed with those inhabiting deeper water.

"It is probable that before the Glacial period began, a warm current, not necessarily the Gulf Stream, supplied the Arctic Ocean with warmth. The cessation of this current gave the first impetus to the formation of ice near the North Pole, the Arctic Ocean being then a closed basin. Two extensive transgressions of the Arctic Ocean now took place, one inundating the plains of Arctic America and the other those of Northern Russia. The latter transgression covered a portion of Northern Continental Europe, and joined the great inland sea, the Ponto-Caspian, by some narrow channels, so that Asia became almost isolated from Europe. The Siberian fauna was, therefore, unable to migrate to Europe, but a number of Asiatic mammals invaded North America, which was accessible by means of a land-passage across Behring Straits. Meanwhile, Arctic marine species found their way to Northern Germany, and to the western portion of the newly-formed North European sea, now the German Ocean.

"The first occurrence of Arctic forms of life in the newer Tertiary deposits on the east coast of England, marks therefore the period when this marine transgression took place, the German Ocean being at that time closed on all sides, except to the east. As Arctic marine species make their first appearance in these English strata in the newer Crags, the latter are synchronous with the Lower Continental Boulder-clay, in which these same species are first met with. This reasoning might be found fault with, but the vast immigration into Europe of Siberian mammals took place after the deposition of the Lower Continental Boulder-clay, during the so-called Interglacial phase of the Glacial period. Now, as the advance-guard of this migration reached England during the time when the Forest-bed was laid down, the supposition of the contemporaneousness of the newer Crags with the Lower Continental Boulder-clay seems to me correct. There is no reason to suppose that the Interglacial era or Forest-bed period was characterized by a much milder climate than that preceding it, but, as it was probably much drier, the glaciers which had formed on the Alps and in Scandinavia receded considerably. The immediate result was a diminution in the amount of detritus carried to the North European sea by icebergs, so that more extensive colonies of marine animals were able to establish themselves on the sea-floor than during the preceding stage of the Glacial period. The narrow straits which had formed across the Tchernosjem district in Central Russia, between the Northern Sea and the greatly enlarged Caspian, ceased to exist in the Interglacial phase, owing to the gradual withdrawal of the Arctic waters from Northern Europe. A slight refrigeration of the Siberian climate was the consequence, and the barrier which prevented egress to Europe being now removed, the Northern Asiatic fauna swarmed across the plains of the newly-opened continent.

"During all this time, Scandinavia remained connected in the north with Greenland, and in the south and west with Scotland and Ireland, but it had no direct communication with the continent, being separated from it by the North European sea. England and France were united throughout the Glacial period, but the connection between the former and Ireland broke down during, or shortly after, the deposition of the Forest-bed, so that none of the Siberian migrants, which now poured into England from the Continent, reached Ireland." (p. 496.)

"It seems to me that the theory of the marine origin of the Boulder-clay offers the following simple explanation:—After the Interglacial phase of the Glacial period had passed away, a renewed transgression of the Arctic waters must have occurred, but the sea did not again invade Central Russia. As Professor J. Geikie has pointed out, the erratics included in the Upper Boulder-clay of Northern Continental Europe have travelled in a different direction from those contained in the Lower. A change of current, therefore, evidently took place owing to the fact that the Northern European sea was not now connected with the Ponto-Caspian basin.[1]

"A large number of erratics would therefore be brought by Scandinavian icebergs stranding on the east coast of England, which was gradually being submerged by the advancing marine transgression. As the water rose, the local glaciers which had begun to form on the mountains of the North of England and Scotland, cast off icebergs which scattered detritus and boulders over the plain." (p. 497.)

"I think the marine theory would explain in a more satisfactory manner than the terrestrial one, the fact of the erratics being carried in a direction contrary to the natural flow of a glacier, if we remember that probably a strong current existed from the more or less closed North European sea to the open Atlantic. The occurrence in almost all the English Boulder-clays of marine shells tells strongly in favour of the view that these clays are of marine origin. Moreover, they are found to contain Arctic species, and these are mixed with southern forms as we approach the land adjoining the Atlantic, where an almost purely Mediterranean fauna had hitherto existed. Arctic forms of life now found their way, not only into the Atlantic, but by the newly-opened Straits of Gibraltar they entered the Mediterranean, and are preserved to us in some remarkable deposits in Sicily." (p. 500.)

"I think Mr. Praeger's conclusions as to the changes in the marine fauna of the north-east of Ireland agree in the main points with those which I arrived at from an independent inquiry into the origin of the terrestrial fauna of that island.

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[1] This, again, is of great importance in establishing the contemporaneousness of [illegible]nental Boulder-clay with the whole of the British clays.

"From the careful study of terrestrial faunas, has been gained not only the knowledge of the changes of climate which have passed over the world. but, in the main, those geographical revolutions which have been produced in North Europe in recent geological times. I trust that I have succeeded in strengthening the old Lyellian theory on the origin of the Glacial period, which has received such strong support from no less an authority than Lord Kelvin."

CORRESPONDENCE.

TRINUCLEUS SETICORNIS.

SIR,—It is interesting to read two remarks occurring in successive numbers of your Magazine. In the August number (p. 379) I wrote: "If Mr. Reed will turn to my Sedgwick Essay . . . . (published in 1883) . . . . he will find *Trinucleus seticornis* recorded as a Middle Bala fossil in North Wales, the Lake District, and Scandinavia, and nowhere recorded in the Upper Bala list."

In the September number (p. 427) Mr. F. R. C. Reed writes: "He [Mr. Marr] mentions in his criticism of my remarks that in 1883 he had stated that this species was nowhere found in the Upper Bala."

I nowhere mention that I have made this statement. and I never did make it. In 1883 *Trinucleus seticornis* had not been discovered in beds recognized as Upper Bala, and naturally I could not record it, but made no statement concerning its absence in Upper Bala rocks. In 1885 it had been discovered, and the discovery was then mentioned by Mr. Roberts and myself. Mr. Reed accuses me of a mistake, because in 1883 I did not record an undiscovered fossil! He ignores the essential point of my letter that *Trinucleus seticornis*, which he states (Q.J.G.S., vol. liii, p. 90) to be a characteristic Upper Bala fossil, is abundant in the Middle Bala beds. J. E. MARR.

CAMBRIDGE, *September* 23, 1897.

MISCELLANEOUS.

THE FOREST-BED OF THE NORFOLK COAST. — This interesting deposit, so rich in organic remains, has been carefully worked for more than twenty years by Mr. A. C. Savin, of Cromer, who during that period had accumulated about 1,900 specimens of Vertebrata, many of which had been described and figured by Mr. E. T. Newton, F.R.S., Prof. Leith Adams, Prof. Lankester, F.R.S., and others. Mr. Savin's collection has just been acquired by the British Museum (Natural History), where it will be preserved for all time, and form a most unique and valuable addition to our National Museum, as well as add greatly to our knowledge of the fauna of this old Pliocene land-surface.

THE REV. P. B. BRODIE, M.A., F.G.S.

Vicar of Rowington, Warwickshire;
President of Warwickshire Natural History and Archæological Society,
President of Warwickshire Naturalists' and Archæologists'
Field Club.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IV.

No. XI.—NOVEMBER, 1897.

ORIGINAL ARTICLES.

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I. — Eminent Living Geologists: The Rev. P. B. Brodie, M.A., F.G.S.[1]

(WITH A PORTRAIT, PLATE XX.)

THE REV. PETER BELLINGER BRODIE was born in London in 1815. His father, Mr. P. B. Brodie, was an eminent conveyancer and barrister-at-law, while his uncle, Sir Benjamin C. Brodie, Bart., the celebrated surgeon, was President of the Royal Society from 1858 to 1861.

While a youth, and resident with his father at Lincoln's Inn Fields, the younger P. B. Brodie acquired a taste for Natural History, and often went as a student to the Royal College of Surgeons. Geology, in these early years, attracted his attention, and to such good effect, that he was proposed as a Fellow of the Geological Society of London by William Clift, the Curator of the College of Surgeons, and he was elected so long ago as January, 1834, just before he went to Cambridge. At that time he was the youngest Fellow ever admitted; now he remains one of the oldest, and, with one exception, the earliest elected of the present Fellows of the Society. H. E. Strickland, with whom in after years Mr. Brodie was much associated, was elected into the Geological Society towards the end of the same year, 1834, and during the Presidency of G. B. Greenough. At this time, Buckland and Conybeare, Sedgwick, De la Beche and Fitton, Murchison and Lyell, were all members of the Council. As Mr. Brodie tells us, he then attended meetings of the Society held in Somerset House, and listened to "many intellectual combats between the geological giants of those days."

Educated afterwards at Emmanuel College, Cambridge, he naturally came under the inspiriting influence of Sedgwick. He regularly attended the lectures of the famous Professor, and voluntarily assisted him in the Woodwardian Museum. Thus Mr. Brodie's early interest in Geology was fostered, and he soon began to undertake original work. His first paper, "Notice on the occurrence of Land and Fresh-water Shells with Bones of some Extinct Animals in the Gravel near Cambridge," was read in 1838 before the Cambridge Philosophical Society, but it was not printed until six years afterwards.[1] Some notes were contributed to this paper by Sedgwick, and it contained the earliest published record of the Mollusca from the now celebrated Pleistocene deposit of Barnwell.

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[1] Some of the particulars given in this brief biography were kindly furnished by the Rev. P. B. Brodie, and others by Mr. S. S. Stanley.

In 1838 Mr. Brodie was ordained deacon, and the same year he was appointed curate to the rector of Wylye, in Wiltshire. The village is situated on the south-western borders of Salisbury Plain, and about four miles to the north of Dinton, in the Vale of Wardour. Here it was that Mr. Brodie became acquainted with that interesting geological region, and his researches added further renown to a district already made famous by the observations of Miss Benett and Dr. Fitton.

In May, 1839, Mr. Brodie read his first paper before the Geological Society of London, entitled "A notice on the discovery of the remains of Insects, and a new genus of Isopodous Crustacea belonging to the family Cymothoidæ, in the Wealden Formation in the Vale of Wardour, Wilts" (Proc. Geol. Soc., iii, 134). The new Isopod was determined by Professor Owen, and subsequently described by Milne-Edwards under the now familiar name of ***Archæoniscus Brodiei***. The strata, in one layer of which this fossil occurs in profusion, have since been grouped with the Purbeck Beds.

Mr. Brodie was admitted to priest's orders in 1839, and he stayed barely two years in his Wiltshire parish. In 1840 he became curate to the vicar of Steeple Claydon, in Buckinghamshire, and entered a region of Oxford Clay and Drift in the vale of Bicester, and a famous hunting country. Steeple Claydon is about four miles south of Buckingham, where the Lower Oolites come to the surface; but Mr. Brodie's observations were directed to the country further south, where he found at Quainton Hill, and at Stone, near Aylesbury, outliers of Portland and Purbeck beds possessing "a certain similarity with those in Wiltshire, but with clearly marked local differences." Staying but a few months at Steeple Claydon, his discovery of remains of Insects and other fossils in the "Wealden" (Purbeck) strata of Buckinghamshire was published after he had left the district (Proc. Geol. Soc., iii, 780).

In 1841 Mr. Brodie was appointed Rector of Down Hatherley in the Vale of Gloucester, and about five miles west of Cheltenham. Here he came into a richly fossiliferous region of Lias and Oolites, and here he had also the advantage of many fellow workers in geology. Strickland's home at Cracombe House, Evesham, was not far away to the north, and those of Dr. Wright and James Buckman lay a few miles to the east. W. S. Symonds, afterwards Rector of Pendock, was from 1843–5 Curate of Offenham, near Evesham; and Lycett must about this time have commenced his labours at Minchinhampton. It was not long before Mr. Brodie announced his discovery of Insect-remains in the Lower Lias in Gloucestershire, and he published sections of the basement-beds of that formation, and of the underlying strata (now grouped as Rhætic), which he had studied at Wainlode and Westbury-on-Severn. He also in the same year (1842) drew attention to the occurrence of fossil plants in the so-called "Plastic Clay" of the cliffs at Bournemouth—a locality since famed for the many plant-remains obtained and described by Mr. Starkie Gardner.

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[1] Trans. Cambridge Phil. Soc., viii, 138.

In 1844 Mr. Brodie was associated with Professor Buckman in a paper on the Stonesfield Slate of the Cotteswold Hills, and, in addition to many stratigraphical details, the authors recorded from the deposit various Insects, Plant-remains, and other fossils. The researches thus carried on by Mr. Brodie opened up quite a new line of study—that of Fossil Insects. In 1845, assisted by Professor J. O. Westwood, he embodied his results in a work entitled "A History of the Fossil Insects in the Secondary Rocks of England." This included a particular account of the strata in which the remains were found; and the work was appropriately dedicated to his old Master, Sedgwick. The volume was the first ever published on the special subject of Fossil Insects. Later on, Mr. Brodie communicated to the Geological Society of London important papers on the Inferior Oolite of Cheltenham, and on the Purbeck Beds of Swindon.

Although not one of the original members of the Cotteswold Naturalists' Field Club, which was founded in 1846, Mr. Brodie soon joined its ranks. In 1850 he read before the Club a sketch of the Geology of Grantham, and in 1853 he communicated remarks on the Lias of Fretherne and Purton, and on certain Pleistocene Deposits in the Vale of Gloucester. It had been his intention "to have investigated the Pleistocene formation generally in Gloucestershire," but the duties of his calling led him away this same year (1853) to the Vicarage of Rowington, in Warwickshire. It was with great regret (as he tells us) that he left so picturesque and instructive a region as that which was embraced by the proceedings of the Cotteswold Club, and his sorrow was increased by the loss of their pleasant meetings, and the parting with many friends, whose companionship had added a charm and a zest to his studies. (Proc. Cotteswold Club, vol. i, p. 246.)

Rowington village, which now became the scene of Mr. Brodie's labours, is situated on the Keuper marls and sandstones, which are covered here and there by various Drift deposits. Fossils were no longer to be so readily obtained. Nevertheless, the Lower Lias was within reach at Wilmcote, some six or seven miles to the south, and an outlier of the same formation occurs near Knowle, about six miles to the north of Rowington. Mr. Brodie continued to devote his attention very much to the same lines of research, extending them at times to the Upper Silurian and passage-beds of Herefordshire, and recording the occurrence therein of *Eurypterus* and *Pterygotus*, as well as land-plants. He still contributed an occasional paper to the Cotteswold Club, on the Inferior Oolite and Lias of Northamptonshire, and on the Lias of Barrow in Leicestershire.

Warwickshire, however, naturally claimed his especial attention. Soon after his arrival at Rowington, he became a member of the Warwickshire Natural History and Archæological Society (founded in 1836), and he was at once elected an Honorary Curator of Geology in the Society's Museum at Warwick. Many years later (1894) he was elected President of this Society. Field-meetings were naturally regarded by Mr. Brodie as essential for the proper pursuit of natural history, and in 1854 he was the means of founding the Warwickshire Naturalists' and Archæologists' Field Club, of which he was the first Vice-President and Honorary Secretary. He was elected President in 1888. Mr. S. S. Stanley, who for some years acted as junior Honorary Secretary of the Warwickshire Field Club with Mr. Brodie, speaks of the new life and energy which the Vicar of Rowington infused among the naturalists and archæologists of Warwickshire. Foremost as a leader in field-excursions, he kindled in many others an interest in science, as much by his unfailing enthusiasm and good-humour as by his wide knowledge and experience.

In 1855, Mr. Brodie was appointed to the rectory of Baddesley Clinton, a neighbouring village to the north of Rowington; and, with the aid of his son, the Rev. F. M. Brodie, he has continued to discharge the many duties connected with his two parishes.

To the Proceedings of the Warwickshire Natural History Society, and of the Field Club, Mr. Brodie has contributed very numerous papers and addresses, dealing largely with the Keuper and Rhætic formations, the Lias, and various Drift deposits. Most important discoveries of Fish-remains, and also of Mollusca, in the Keuper formation of Warwickshire, have thus been recorded; while the tracts of Lower Lias on the borders of Shropshire and Cheshire, and in Cumberland, have not been unnoticed.

In 1858 Mr. Brodie contributed a series of articles on the Geology of Gloucestershire to the first volume of the *Geologist*, and since then he has sent many papers to the Geological Society, the British Association, and the GEOLOGICAL MAGAZINE. Among these articles, those on the Purbeck Beds of Brill, and the Rhætic Beds near Wells, in Somerset, may be mentioned. So recently as August of the present year he sent a communication to be read at the field-meeting of the Warwickshire Naturalists' Club, held at Wilmcote.

In the course of his long life, Mr. Brodie has formed a most valuable and extensive geological collection, estimated to comprise upwards of 25,000 specimens. The rarer and unique examples have now been placed in the British Museum (Natural History), Cromwell Road; others have unfortunately been dispersed among foreign museums, and a considerable portion in one of our Colonies.

In 1887 the Murchison Medal was awarded to Mr. Brodie by the Council of the Geological Society, and at that date the President, Professor Judd, remarked: "Never, probably, has an award of this Society been made to one who can look back upon so long a record of faithful services to Geology as yourself. . . . . A dweller in the provinces, you have shown how the advancement of our science may best be promoted under those conditions."

The ten subsequent years have tended in no ways to decrease the enthusiasm which Mr. Brodie has ever manifested in the pursuit of geological science. Owing to advanced age, he has had lately to relinquish the office of rural dean of Warwick, which he held for many years; but we trust he may yet be spared some years longer for the tranquil enjoyment of his parochial work in the pleasant home at Rowington. H. B. WOODWARD.

II.—THE CHALKY BOULDER-CLAY AND THE GLACIAL PHENOMENA OF THE WESTERN-MIDLAND COUNTIES OF ENGLAND.[1]

By HORACE B. WOODWARD, F.R.S., F.G.S.

THE extent of the glaciation in the Western-Midland Counties of England during the formation of the Chalky Boulder-clay has yet to be determined in detail. No accurate survey has at present been made of the various Drifts that are scattered over the country from Northamptonshire and Buckinghamshire on the east to Worcestershire and Gloucestershire on the west; but the observations of Strickland, Brodie, Lloyd, Lucy, and others, have made known the characters of the superficial deposits at numerous localities in and around the vale of Evesham, while the probable limit of the action of land-ice during the period of maximum glaciation has been delineated on a small map by S. V. Wood, jun.[2]

The district is of considerable interest as being on the borders of the large region which was mantled by the ice-sheet during the accumulation of the Chalky Boulder-clay of East Anglia; and it was not affected by any marked glaciation during the later phases of the Pleistocene period. The "Modified Drifts" which, in the form of valley-gravels and loams, succeeded the Boulder-clay, yield, as at Cropthorne, the Mammoth and associated fossils; and these deposits merge into the old estuarine and marine deposits of the great Severn Valley.

The probable southern limits of the Chalky Boulder-clay in England may be traced from Hornchurch in the Thames Valley to the north of London and Watford, and thence from the neighbourhood of St. Albans, round by Luton and Leighton Buzzard, into the vale of Aylesbury. A rough boundary may thence be traced between Bicester and Buckingham, to the north of Banbury, and into the vale of Moreton. Finally, the limits must be sought to the north of the Cotteswolds and Bredon Hill, the evidences of ice-action being discernible here and there in the vale of Evesham.

It is noteworthy that the elevated regions of Edge Hill and the Cotteswolds appear to have arrested the progress of land-glaciation. This seems also to have been the case along the higher parts of the Chiltern range, from Wendover to Tring and Dunstable, and these elevated Chalk areas are indeed marked by S. V. Wood, jun., as having been free from the ice which formed the Chalky Boulder-clay. In other places, as along the Liassic scarp near Catesby in

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[1] Read before the Meeting of the British Association at Toronto.

[2] Quart. Journ. Geol. Soc., vol. xxxviii, map 4, pl. xxvi.

Northamptonshire, and in certain Midland areas, there is a local absence of Boulder-clay and of signs of glaciation—an absence not always to be attributed to subsequent denudation, but rather suggesting that the margin of the ice-sheet was prolonged here and there into tongues or broad lobes, as in the vale of Moreton, the low grounds near Buckingham, and the lower areas of Chalk and Tertiary strata in Hertfordshire.

Prior to the formation of the Chalky Boulder-clay in the more central portions of England, we may picture an area whose main features did not differ very largely from those of the present time. The stonebrash hills, in the now glaciated tracts, may have stood out somewhat more prominently from the clay vales in the Jurassic areas, and the country was thickly coated with weathered rock or rubble. The Chalk areas were more extensively covered with clay-with-flints, and with outliers of Tertiary clays, sands, and gravels; while, over the barer tracts of Chalk, the rock itself was much broken up at the surface, and the loosened blocks were in places weathered into a somewhat rubbly form. Hence the greater portion of the land was covered with disintegrated rock and loose superficial strata, such as would readily be frozen into the base of a sedentary ice-sheet, if formed, as in North America, in the way so clearly depicted by Mr. W. O. Crosby.[1]

That the contents of the Chalky Boulder-clay vary to a noticeable extent in accordance with the nature of the strata over which the ice passed, is a well-established fact: nevertheless, the Boulder-clay maintains over a wide area its characteristic chalky ingredients.

It thus appears remarkably uniform in character in its extent from Norfolk to Essex, and from the Eastern Counties to Northamptonshire and Buckinghamshire—a feature mainly due to its abundant chalk and flint. More chalky in West Norfolk, it is more clayey in South Norfolk, Cambridgeshire, Suffolk, and Essex, where Kimeridge Clay and London Clay have been incorporated with other materials in the Boulder-clay. In Huntingdonshire the Oxford Clay, and in Northamptonshire the Lias Clay, have contributed to the Drift a marked amount of débris. A local character has likewise been imparted by the harder outcropping strata over which the Boulder-clay has been distributed.

Along the Midland branch-railway between Bourn and Saxby, very fine cuttings of Chalky Boulder-clay were opened up. The country was trenched in an east-and-west direction from the Oxford Clay of Bourn to the Lower Lias near Melton Mowbray. Amongst the Jurassic materials in the Boulder-clay there was a noteworthy preponderance of Oxfordian fossils in the eastern, of Great Oolite fossils in the central, and of Lias fossils in the western portion of the area.[2]

Cuttings along the new London extension of the Manchester, Sheffield, and Lincolnshire Railway (now termed the Great Central

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[1] Geol. Mag. 1897, p. 321: abridgment of article on Englacial Drift in *Technology Quarterly*, vol. ix, Boston.

[2] H. B. W., "Jurassic Rocks of Britain," vol. iv, p. 422.

Railway), have trenched the country in a north-and-south direction, and very fine sections of Chalky Boulder-clay were exposed between Catesby and Quainton Road, near Aylesbury. The Middle Lias fossils were noteworthy ingredients of the Boulder-clay in the north, and those of the Oxford Clay in the south. In none of these cuttings were there exposed any very large boulders or "cakes" of Secondary rock.

Chalky Boulder-clay occurs in various parts of Warwickshire. It was recognized near Rugby by S. V. Wood, jun.,[1] and in other localities by the Rev. P. B. Brodie[2] and by Mr. W. Andrews.[3] T. G. B. Lloyd[4] observed purple-coloured Boulder-clay containing Chalk, etc., on the Lower Lias area in north-east Warwickshire; and it is likely that in this county, as elsewhere, coloured clays from the New Red Series have been disseminated with other materials in the Boulder-clay.

The most distant evidence of Boulder-clay in the south-western region is that to which attention was directed in 1853 by Mr. G. E. Gavey.[5] The Drift, comprising Boulder-clay, gravel, and sand, was exposed in the railway-cuttings at Aston Magna and Mickleton, and at the time Mr. R. F. Tomes obtained glaciated Chalk from this Drift.[6] In connection with the discovery, it is interesting to note that pebbles of hard red and white Chalk were found by Buckland in 1821, to the south-east of Shipston-on-Stour.[7]

It may be remarked that the "Boulder-clay" to which Mr. W. C. Lucy has called attention as occurring on the Cotteswold plateau, is simply clay with "Northern Drift" pebbles. It occurs in pockets or fissures of the Inferior Oolite here and there, but in itself it affords no evidence of glaciation. Moreover, the so-called "Northern Drift" in the lower portions of the Severn Vale is reassorted, and no doubt derived its erratic pebbles from Boulder-clay in the upper parts of the Severn drainage-area.

To the north-west of Leafield, and at Combe near Woodstock, the higher elevations of Oxford Clay have a thin covering of soil with pebbles of quartz and quartzite. This gravelly soil lies irregularly on the clay, and penetrates it in hollows to a depth of three or four feet, having no doubt descended in cracks which have opened in the clay during very dry weather. Drift of this character affords no evidence of glaciation.

That the Cotteswolds themselves have not been glaciated, is shown by the thick accumulations of oolitic rubble which flank their slopes. Even the Bredon outlier of Inferior Oolite exhibits at the surface 30 or 40 feet of rubble. The rock, indeed, is irregularly weathered, and the resulting gravelly detritus contains in its midst isolated masses and pinnacles of unweathered limestone. Some of the more remarkable accumulations of rubble occur to the north-west of Break Heart Hill, south of Dursley; near Gravel Farm, south of Harescomb; at Leckhampton Hill, where the rubble is banked up at angles of 30° or 40°; and west of Syreford, near Andoversford. Frequently there is a considerable thickness of brown loamy clay on top of the oolitic rubble—the residue of atmospheric waste, indicating some lapse of time.

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[1] Quart. Journ. Geol. Soc., vol. xxvi, p. 224, and GEOL. MAG. 1870, p. 18.

[2] Quart. Journ. Geol. Soc., vol. xxiii, p. 209, and Rep. Brit. Assoc. for 1865, p. 49.

[3] Proc. Warwickshire Nat. Club for 1884, 1885, p. 32.

[4] Quart. Journ. Geol. Soc., vol. xxvi, pp. 205–6. See also A. H. W. Ingram, ibid., xxxv, p. 678.

[5] Quart. Journ. Geol. Soc., vol. ix, p. 29.

[6] Proc. Cotteswold Club, vol. vii, p. 60.

[7] Trans. Geol. Soc., vol. v, p. 518; Reliq. Diluv., 1823, p. 250.

This material has been described by Strickland, Hull, Lucy, Witchell, Prestwich, and others. Mr. Lucy connected the distribution of the rubble with soil-movements, the weathered rock slipping down the hill-sides during times of thaw after severe frost.[1] In Witchell's opinion, this Rubble Drift was "due to storm-waters or surface-drainage, which brought the detritus down the hill upon a frozen surface, and deposited it in those places where the frost usually disappeared in spring before it left the higher ground."[2] Both explanations may be to a certain extent true, and they accord much better with the facts than does the explanation of Prestwich, whereby this Rubble Drift would be due to the effects of wide submergence.[3]

In studying the general characters of the Glacial Drift, several problems of special interest come under notice. Among these are the abundance and wide distribution of chalky detritus; the disturbances produced in underlying strata; the occurrence of the larger blocks or "cakes" of local origin; and the intercalation of the gravels and sands with the Chalky Boulder-clay. If, following Crosby, we believe that the earlier action over the glaciated areas was the removal of the weathered soil and subsoil which was frozen to the base of the at first sedentary ice, we may conclude that the major disturbances in the underlying strata were then produced, together with the striated pavements which are very rarely, of course, to be found in these Midland areas Although "drag" is not admitted as a likely mode of transport of the ground-moraine, yet, when this material was in movement at the base of the ice-sheet, and as it was shifted from its original position, there may have been some dragging of the substrata, leading to contortion and "terminal curvature."

The researches of Messrs. Chamberlin, Upham, and Crosby have shown how materials from the ground-moraine become "englacial" —being carried by overthrusts of ice to higher positions in its mass. In fact, much detritus is thus shifted along planes of slipping, when inequalities in the land cause higher portions of the ice to move obliquely upwards and over lower portions. Parts of the original stony base of the ice-sheet may here and there, however, have been left in the hollows of the irregular land-surface until the final melting of the ice. Had the icy agent overspread the Cotteswold region, the Rubble Drift before-mentioned would have largely contributed its materials to the Boulder-clay, as elsewhere such weathered rock has been removed, and incorporated into the Drift.

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[1] Proc. Cotteswold Club, vol. v, p. 43.

[2] Proc. Cotteswold Club, vol. vi, p. 150; see also H. B. W., "Jurassic Rocks of Britain," vol. iv, pp. 462-3.

[3] Quart. Journ. Geol. Soc., vol. xlviii, p. 314.

In parts of Norfolk where the bare Chalk comes to the surface, it now weathers into a kind of rubble, as may be seen near Wells; and, land-ice overspreading such a surface, the superficial layers would be frozen to its base, and, with the aid of a little Kimeridge Clay, the Chalky Boulder-clay would be readily formed. During the movement of the ice-sheet the lumps of chalk would become scored by pressure against tiny fragments of shattered flint and other hard rocks, along the shearing planes of the ice. As remarked by Crosby, the detritus reaching the highest levels in the ice is carried farthest, and we may infer that such was the case with so much débris of Chalk, the harder fragments of which have mostly suffered faceting and striation. This would occur along the many minor planes of movement in the ice which Chamberlin has so clearly pictured.[1]

Thus, on the melting back of the ice, the further travelled Chalk and flints became commingled with the more local débris; and when a subsequent movement of the ice took place, the ground-moraine was pressed into the tough material of which the Chalky Boulder-clay so generally consists, and this subjacent drift was itself disturbed in many places, and dislocated as if by faults.

It should be borne in mind that in certain areas, as in East Norfolk, an earlier Boulder-clay, the Cromer Till, no doubt furnished some erratics to the Chalky Boulder-clay which overspread it; while other travelled stones may have come from ice proceeding from western and north-western areas overriding the ice of the Eastern-Midland plain. Pebbles of quartz and quartzite may in part have been derived from Tertiary gravels, as remarked by Sir Henry Howorth.[2]

In his account of Ice-work in Edenside Mr. J. G. Goodchild long ago maintained that Boulder-clay was not dragged along between the ice-sheet and the rocks beneath, but that it was formed of the weathered detritus of the rocks and other loose material, and deposited on the melting of the ice at or not far from the areas where the Boulder-clay is now found. He also refers to the different currents of ice that may have been present over an area undergoing land-glaciation, and to which causes many admixtures of boulders from diverse localities may be due.[3] Other explanations of the "intercrossing of erratics" have been given by Mr. Clement Reid and Mr. Lamplugh, who point out that stones from various localities may have been scattered over the bed of the North Sea by floating-ice prior to the invasion of the area by land-ice, and many of these boulders would then become incorporated in the subsequent ground-moraine.[4]

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[1] See "Recent Glacial Studies in Greenland": Bull. Geol. Soc. America, vol. vi, p. 199.

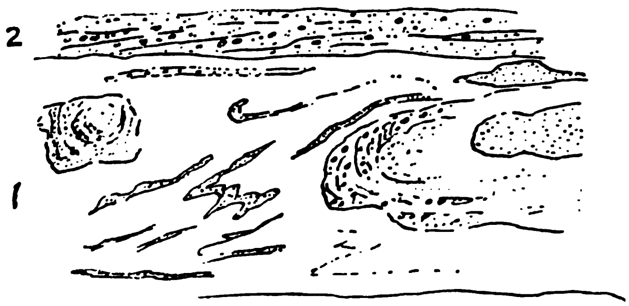
[2] Geol. Mag. 1896, pp. 455, 463.

[3] Quart. Journ. Geol. Soc., vol. xxxi, p. 55; and Trans. Cumberland Assoc., No. 11, 1887, p. 111.

[4] Reid, "Geology of Cromer," p. 90; Lamplugh, Geol. Mag. 1890, p. 67.

That the main features of the glaciated portions of the country were carved out very much as they are now before the accumulation of the Chalky Boulder-clay, is evident when we consider its distribution. It lies in patches, or great sheets, on the Oolitic uplands, from Stow Park, near Buckingham, to Lincolnshire, and on the Chalk plateaus from near St. Albans to Norfolk and the Lincoln wolds; it is found also in the vales beneath the escarpments, and near South Willingham, in Lincolnshire, it crosses the Cretaceous scarp. Its tendency, as a rule, has been to efface the old scenery, and the subsequent agents of denudation have only carved out minor valleys and separated the Boulder-clay into great sheets and numerous large and small outlying masses. The incorporation of so much Cretaceous and Jurassic material in the Boulder-clay, of course, means a great amount of erosion, but this, as a rule, took place from a scouring of the irregular land-surface, and was attended by a degradation rather than an intensification of the main features.

FIG. 1.—Pit by spinny, north-west of Thorpe Limekiln, Norwich.



2. Gravel and sand, 3 or 4 feet. PLATEAU DRIFT.
1. Stony loam with contorted seams and masses of sand and gravel, 16 feet. CONTORTED DRIFT.

When the agent which accumulated the Boulder-clay acted with greater power, the Chalk escarpment was considerably abraded, as in West Norfolk, and onwards to the neighbourhood of Stevenage and Hitchin. To the south-west we find no evidence of this planing down, the escarpment of the Dunstable and Luton Downs is bold, and so it is continued along the further range of Chiltern Hills. We do not find any Boulder-clay on the crests of these higher hills. Nevertheless, we find no Boulder-clay on the crests of the Lincolnshire Cliff, and this fact shows that we must be cautious in inferring an absence of glaciation where no relics at present exist. The presence, or absence, of loose and weathered rock, and other circumstances, must here aid our conclusions. Thus, in West Norfolk there is a marked absence of Clay-with-flints.

It is admitted that ice moving over ground-moraine cannot at the same locality erode.[1] Whether all the disturbances which we find in the upper layers of the subjacent strata were produced prior to the deposition of the Boulder-clay, may be open to question, but no doubt the majority were. S. V. Wood, jun., indeed, referred certain disturbances in the strata to a time when "this antecedent cushion of moraine" had been cut through by the ice.[1] He gave instances in the Oxford Clay near Huntingdon, in the Chalk near Litcham, and in the Contorted Drift near Norwich—the last instance being especially noteworthy when we bear in mind Wood's views regarding the Contorted Drift of the Cromer coast, the disturbances in which he attributed to grounding icebergs. The section Fig. 1, which I noted in 1876, is probably the one referred to by Wood.

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[1] J. R. Dakyns, GEOL. MAG. 1875, p. 169.

Dealing now with the contorted underlying strata, we find evidence of their being generally disturbed by glacial action prior to the accumulation of the Boulder-clay. I have elsewhere figured disturbances in the Upper Lias Clay beneath Chalky Boulder-clay at Gayton Wharf, near Blisworth, in Northamptonshire;[2] and a disturbed surface of Great Oolite Clay and rubble beneath Boulder-clay at Maidford, north-west of Towcester.[3] In this latter case, as in another instance near Radstone, in Northamptonshire, it would seem that locally the severed soil and rubble had not been moved far—the stony base of the ice-sheet being perhaps arrested and overridden.

As before remarked, glaciated pavements in the Jurassic and newer formations of the Midland or Eastern Counties have but rarely been noted, nor could they often be produced in such easily disturbed strata. The most interesting example is that observed by Mr. W. J. Harrison in a cutting made in 1874–5 in widening the Midland Railway between Leicester and Wigston. Referring to the Boulder-clay, he remarks that "Its thickness here was between 20 and 30 feet. At the base the lower lias shales and limestones were exposed to a depth of 3 or 4 feet for a distance of about 400 yards. The limestones were most beautifully striated *in situ*, the slightness of the dip having prevented the ripping up of the beds to any great extent, and the thick covering of clay having preserved them from the percolation of water. Oblong slabs of limestone, torn off, were to be seen lying in close proximity to the outcrop of each stratum, and a little to the south of it. In one spot the strata were bent up for a few yards into a sharp anticlinal curve."[4]

Where Boulder-clay rests on the New Red Sandstone in Icknield Street, Birmingham, it was observed by Crosskey that in places large fragments of sandstone had been disrupted and thrust into the middle of the Drift; elsewhere a part of the sandstone had "been lifted up almost like an arm," while the Drift had been accumulated beneath it.[5]

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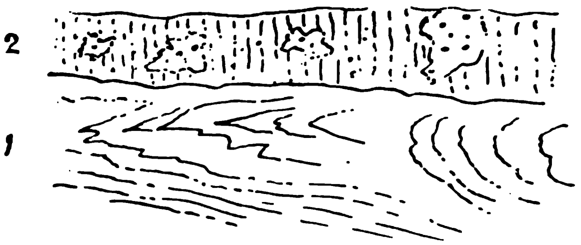
[1] See Quart. Journ. Geol. Soc., vol. xxxvi, pp. 482–90; and vol. xxxviii, p. 667.
[2] "Jurassic Rocks of Britain," vol. iii, p. 277.
[3] Ibid., vol. iv, p. 397; and Geol. Mag. 1897, p. 103.
[4] "A Sketch of the Geology of Leicestershire and Rutland," 1877, p. 45.
[5] Proc. Birmingham Phil. Soc., vol. iii, p. 213.

The Rev. J. M. Wilson noticed that at Bilton, near Rugby, the Lias Clay was contorted beneath glacial sand and gravel.[1] In that neighbourhood the Drifts lie very irregularly on the Lias, and there is evidence of sand and gravel above as well as below the Boulder-clay.

In 1870 Mr. C. J. Woodward drew attention to certain "Swilleys" or disturbed surfaces in the Lower Lias of Grafton and Binton, in Warwickshire. His illustrations depict these features as identical with others in the same district to which I have subsequently drawn attention—in ignorance at the time of his much earlier observations.[2]

At Church Honeybourne, east of Evesham, the Lower Lias Clay is contorted, and again at South Littleton the exposed beds of limestone and clay were nipped up on the surface in a series of sharp folds. As far west as Croome D'Abitot, near Pershore, in Worcestershire, similar evidences of surface-disturbance were observed.[3] Probably the "Lias clay with contorted beds of Lias limestone" noted in the railway-cutting at Dunhamstead by Strickland, in 1840, exhibited features of the same character.[4] At Halford, north of Shipston-on-Stour, I noticed that the beds of White Lias were much disturbed in places.

FIG. 2.—Section about one mile south of Surlingham St. Mary, near Norwich.



2. Brown stony loam (decalcified Boulder-clay) with unweathered remnants of Chalky Boulder-clay, 3 feet.
1. Blue clay and laminated clay and sand: contorted, 5 feet.

In this region, although the disturbances are similar to those produced by glacial action, we have (with the exception of the Aston Magna Drift) no distinct evidence of Boulder-clay, the superficial deposit being a few feet of reddish-brown clay with pebbles of quartz and quartzite. This is no doubt the deposit described by T. G. B. Lloyd as "light-red, sandy, unstratified clay, compact and hard, containing quartzose pebbles and a few boulders, which occasionally exhibit traces of glacial action." He observes that it is the "General Quartzose Drift" of Strickland and the "Northern

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[1] Quart. Journ. Geol. Soc., vol. xxvi, pp. 194, 196; and Rep. Rugby Nat. Hist. Soc. for 1869, p. 30.

[2] Proc. Birmingham Nat. Hist. Soc. for 1870, p. 63. The labours of Mr. W. J. Harrison in preparing a bibliography of Midland Glaciology were thus appreciated. Mr. Harrison has since published a similar work for Norfolk.

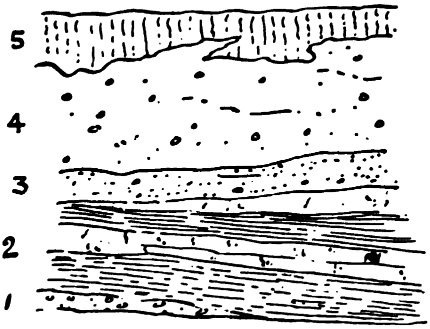
[3] H. B. W., "Jurassic Rocks of Britain," vol. iii, pp. 146, 150.

[4] Proc. Geol. Soc., vol. iii, p. 314.

Drift" of Murchison.[1] This Drift occurs here and there over a wide area in Warwickshire, and may be a result of the denudation of Boulder-clay.

During the progress of the Geological Survey in Norfolk and Suffolk, numerous instances of contortion in the strata underlying the Chalky Boulder-clay, and occasionally of intrusive tongues of that material, were noticed.[2] Chalk and Crag were in places disturbed, but the marked contortions were usually to be found where brickearth or clay, or thin alternating clays and sands, lay beneath the Boulder-clay. (See Fig. 2.) Where glacial muds. formed during temporary recession of the ice, were afterwards overridden, erosion without marked contortion was sometimes to be seen. (See Fig. 3.)

FIG. 3.—Pit one-quarter of a mile north-west of Dove Inn, Poringland, Norfolk.



5. Soil and decalcified Boulder-clay, 2 or 3 feet.
4. Chalky Boulder-clay. } 6 or 7 feet.
3. Chalky sand (base of Boulder-clay). } 6 or 7 feet.
2. Yellowish laminated clays and bands of marl, 6 feet.
1. Chalky Boulder-clay.

Thick beds of yielding sand are, as a rule, but little, if at all, disturbed, as may be observed in the well-known coast at Kessingland, and again where the Boulder-clay rests on the remarkably false-bedded Lower Greensand at Grove Bury, near Leighton Buzzard. At the last-named locality, where the sections were noted by Mr. A. C. G. Cameron,[3] portions of the sand have been torn away and incorporated with the Boulder-clay, but the main mass of the Lower Greensand is wholly undisturbed. Sands which had been frozen to the base of the ice-sheet may have been so removed, but in their severance from the main mass of underlying sand no disturbance was therein produced.

Intruded masses of Chalky Boulder-clay have been noticed, not only beneath uptilted Chalk, but in the midst of soft gravels and

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[1] Quart. Journ. Geol. Soc., vol. xxvi, pp. 205–6. See also paper on Gravels by H. J. Osborne White: Proc. Geol. Assoc., vol. xv, p. 157.

[2] "Geology of Stowmarket," by W. Whitaker and others, p. 9; "Geology of Bury St. Edmunds and Newmarket," by F. J. Bennett and J. H. Blake, p. 11; "Geology of Norwich," by H. B. Woodward, p. 112.

[3] See Ann. Report of Director-General of Geol. Survey for 1896, p. 79.

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"a mass of Boulder Clay apparent
Portions of these older deposits w
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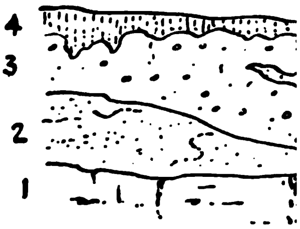
FIG. 4.—Section at (



4. Soil and decalcified B
3. Chalky Boulder-clay.
2. Sands and gravels (Cr
1. Chalk.

Intrusive tongues, of course, can
a manifest disturbance of the strata
clay so introduced, or when the Drift
unquestionably of older date. The
ham by Crosskey may here be consi

The larger masses or "cakes" of

the great Chalk boulders, belong to the period of the greatest glaciation, or of the Chalky Boulder-clay.[1] My own observations in Norfolk coincide, as the disturbed Chalk at Trowse was clearly connected with the Chalky Boulder-clay; so also were sundry remarkable disturbances in the Chalk near Wells.[2]

The long-disputed Boulder of Chalk at Roslyn Hole, Ely, is in direct association with the Chalky Boulder-clay; so also is the large tract of Chalk and rearranged Chalk discovered at Catworth by Mr. Cameron.[3] Again, the well-known masses of Lincolnshire Limestone that occur in the Drift at Great Ponton, as first observed by Professor Morris, are associated with the Chalky Boulder-clay, occurring in these and other cases at or near the base of the Drift.

A large transported mass of Marlstone, more than 200 yards across, was found by Professor Judd capping Beacon Hill, south of Swayfield. He remarks: "It is noteworthy that these masses always belong to the rocks which form the highest ground," and that "Some of the masses of the Marlstone Rock-bed have been carried across deep valleys, a distance of probably not less than 30 miles." He then attributed their transportation to floating-ice.[4]

More recently Mr. Fox-Strangways has observed "a mass of Lincolnshire Oolite, at least 300 yards long and 100 yards broad," to the north-west of Melton Mowbray,[5] and also a mass of Marlstone, 12 feet across, near Dunton Basset.[6] These also were included in the Chalky Boulder-clay.

Far west again, in the elevated region of the South Wales Coalfield, a transported mass of Carboniferous sandstone upwards of 200 yards in length has been discovered by Mr. W. Gibson. "Though its bedding is only slightly disturbed, yet the whole mass has been ascertained to lie upon Boulder-clay, and must therefore be regarded as a huge boulder."[7] It is interesting to note that Chalk-flints have been found in the Drift of this region; and, although we have no positive evidence to assert that it is of the same age as the Chalky Boulder-clay of the Midland and Eastern Counties, yet we may well believe that it belongs to the period of maximum glaciation.

Looking to the source of the larger cakes of Cretaceous and Jurassic rocks, we find that they occur in areas where the formations from which they were detached suffered marked denudation. As previously mentioned, the Chalk areas along the Fenland borders had been planed down, and it will be noticed that there is a singular absence of Jurassic outliers along the western margin of the great Lincolnshire "Cliff," and this absence may reasonably be attributed to their removal during the Glacial period.

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[1] "Geology of Cromer," pp. 111–117.

[2] Quart. Journ. Geol. Soc., vol. xxxv, p. 106 (Proc.); "Geology of Norwich," p. 135; "Geology of Fakenham," etc., p. 22.

[3] Proc. Geol. Assoc., vol. xiii, p. 356.

[4] "Geology of Rutland," etc., pp. 246–7.

[5] Report of Director-General of Geol. Survey for 1892, p. 249.

[6] Geol. Mag. 1897, p. 57.

[7] Report of Director-General of Geol. Survey for 1894, p. 275.

Judging by facts, we may believe that these cakes and boulders were in some cases dislodged from outliers frozen to the base of the land-ice, and shifted to higher levels in the ice along planes produced by its movement over an irregular surface. Cliffs or escarpments, as well as outliers, locally formed impediments to the progress of ice.

As is well known, the Chalk in Norfolk, at Whitlingham, Trowse, and Trimingham, was markedly disturbed, and the evidence brought forward by Mr. Clement Reid and myself shows that great force must have been exerted, sufficient to bend the Trimingham Chalk into folds, and to uptilt the Trowse Chalk, whereby we see stages in the formation of the huge cakes of Chalk elsewhere disrupted and incorporated with the Drift. Cliffs that had been formed in the Chalk along Pliocene coast-lines may then have been effaced.

It is, of course, by no means improbable that some of the large masses of rock may have slipped from scarps on to ice when the ice-sheet was being temporarily melted back, and they may thereby have become incorporated into the subsequently thickened moving ice.[1]

At Hendon and Finchley masses of reconstructed London Clay have been incorporated in the gravelly Drifts, and these may have been torn from the parent strata during an early stage of the period of maximum glaciation.[2]

If we believe that the main mass of Boulder-clay was deposited on the melting back of the ice-sheet, or from the melting of basal portions of the ice, and that there were alternations in the climate so that the ice extended and receded for some distance more than once before it finally retreated, we can understand the intercalation of water-distributed sands and gravels, as well as laminated muds, with Boulder-clay, and more especially along the margin of the glaciated area. Such instances would, no doubt, follow the final retreat of the ice, and we have indeed examples at Wymondham, in Norfolk, of fine sand and coarse gravel interbedded with Chalky Boulder-clay. Instances are more frequent towards the southern area. Mr. Whitaker long ago drew attention to the intercalation of Boulder-clay in the sands and gravels of Hertfordshire, and there are fine examples at Tingewick, Radcliff, and elsewhere, near Buckingham, where coarse boulder-gravel with large blocks of Jurassic and other rocks, and finer gravel and sand, occur in association with the Boulder-clay.

The extensive tracts of gravel and loam on the Chalk areas of Buckinghamshire, in the vicinity of Chesham, Amersham, and Rickmansworth, may to some extent have resulted from the melting of ice, and the more or less torrential distribution of material, including large greywethers. Some beds of gravel were doubtless distributed during the earlier stages of the period of maximum glaciation, and they would yield an abundance of Jurassic fossils such as we find in Drift gravels in Cambridgeshire, Huntingdonshire, and Hertfordshire. In many places Belemnites and Gryphæas are preserved when other fossils and fragments of limestone have been dissolved away. Some of these gravels have naturally been used up time after time, and probably only in the later of the gravels, except where protected by Boulder-clay, do we find many pebbles of Chalk or other kinds of limestone.

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[1] See also T. M. Reade, Quart. Journ. Geol. Soc., vol. xxxviii, p. 232, and G. A. J. Cole, Geol. Mag. 1895, p. 553.

[2] See discussion on paper by Dr. Hicks, Quart. Journ. Geol. Soc., vol. xlvii, p. 583.

III.—On some Rock-Specimens from Kimberley, South Africa.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

(*Concluded from the October Number*, p. 453.)

2. *Dykes and other Igneous Rocks.*

ALTHOUGH not strictly in the order of the title, we may describe first a specimen from the so-called "melaphyre," which forms a great sheet high up in the group through which the diamond-bearing pipes have been driven. This, which bears the label "No. 5, Melaphyre," is nearly 5″ in length. Macroscopically, it may be described as a compact dark basalt, showing slight signs of decomposition, and containing rather sparse amygdales of irregular size and shape (the maximum length being about half an inch), filled mostly with calcite and spotted occasionally with dark-green. The specific gravity is 2·842. Microscopic examination shows the following constituents: (*a*) Plagioclase: microliths of this form a large part of the ground-mass, varying generally from about ·005 to ·007 in length, with a fair number nearly four times this size, but two or three, probably of earlier date, are from four- to six-tenths of an inch. Among these microliths are scattered granules and small grains of iron-oxide; also a filmy green mineral, exhibiting aggregate polarization, but whether it represents a pyroxene or a residual basic glass is not easily determined. Larger grains of augite indubitably have been present, which, however, are now replaced by acicular hornblende with parallel grouping. In addition to this, needles of this mineral, grouped in tufts, pierce, like pins, into the larger felspars. The latter are not in good preservation; they contain granules of iron-oxide and green specks. Vesicles from about one-twelfth of an inch downwards are found to be fairly numerous: they are now filled by a pale dull-green chlorite, which exhibits pleochroism from an ochre-yellow to a green, giving low polarization tints and apparently straight extinction. Now and then a grain or two of calcite or of epidote may also be present, especially in those of larger size, in which calcite dominates. Other enclosures occur: three wholly included, one, the largest (which cannot have exceeded a quarter of an inch in diameter), almost wholly; besides two others doubtful in nature because so little is left. Round each is a slightly interrupted zone of chlorite, usually not more than ·01″ broad, and sometimes a little calcite. They appear to be quartzite, but the structure is rather peculiar. The inner part consists of grains of quartz, with the usual somewhat irregular outline. Certain of these, under crossed nicols, exhibit a slightly radial structure. This might be the result of strains in an exceptional direction, but it seems more likely to have been assumed during the formation of the grain. The outer part of the fragment, about one-eightieth of an inch wide, exhibits a chalcedonic structure, which seems to cut across the contiguous grains of quartz, and continues successively the dominant tint of each of these. I think this chalcedonic zone most probably the result of an external alteration of the original fragment and a phenomenon of contact metamorphism. There are a few enclosures and cavities in the quartz grains themselves, but these generally do not call for remark, except that one or two grains are crowded with very minute rounded spots of a light-brown material which appears to be anisotropic. I think these fragments come from the quartzite or quartz-grit, which is occasionally interbedded with the dark shales, and that they have been caught up by the "melaphyre." The latter perhaps is rather a diabase than a basalt, and is almost certainly a flow.

A specimen labelled "Basalt," without number or depth, looks as if it might be part of a rudely spheroidal mass; it appears to be a very fine-grained dolerite, and under the circumstances I have thought a microscopic examination needless.

"Igneous dyke No. 8, 1,200-feet level": is an irregular fragment of a dark-coloured, very fine-grained dolerite, its s.g. being 2·989. Microscopic examination shows that it consists mainly of four minerals: (*a*) Felspar, ill preserved, replaced by microliths, probably once plagioclase. (*b*) Augite, fairly idiomorphic, with characteristic cleavage, slightly brown in colour; showing at the exterior incipient replacement by a filmy green hornblende. (*c*) Prisms of a dull-greenish mineral enclosing flattish granules of opacite. This mineral (clearly secondary) occurs in parallel fibres or needles with slightly oblique extinction, and so probably is hornblende. The original mineral possibly might have been an enstatite, but I think some unstable form of augite is more probable. (*d*) Grains and occasional rods of iron-oxide sometimes passing externally into limonite. We also find small flakes of biotite; clear acicular microliths (? actinolite) piercing the felspars, and two or three grains, similarly pierced, of a water-clear mineral, like quartz, but probably a secondary felspar. Hence the rock is a rather altered dolerite, approaching a diabase.

"South of dyke No. 10, 1,200-feet level." This is a rather irregularly-shaped fragment, partly bounded by rude joint faces, a little more than six inches in length, of a dark, slightly speckled basaltic rock with a few irregular grains of pyrite. The slice exhibits the following minerals: (*a*) plagioclastic felspar, more or less replaced by secondary products; (*b*) brownish augite of dirty aspect, due to decomposition; (*c*) rather elongated prisms of a pale-green serpentinous mineral retaining indications of a platy cleavage, probably an altered enstatite; (*d*) iron-oxide in crystalline grains, sometimes also in rods or plates; (*e*) pyrite, occasionally forming an aggregate of crystalline grains; (*f*) a few grains of calcite. The iron-oxide and the supposed enstatite appear to have crystallized first. I expect the crystallization of the augite and felspar was almost simultaneous. The augite and the enstatite are often closely associated, and sometimes two long prisms of the former enclose one of the latter, like a section of a sandwich. The rock may be called an enstatite diabase.

"Hard rock No. 18, 1,500-feet level": a dark basaltic rock, slightly speckled with grey, and with occasional grains of felspar. The specimen is about 5¼" × 4" × 2". The minerals are practically identical with those in the last rock, but the augite is more often idiomorphic; rods of iron are more frequent, and these sometimes form rude gratings. Thus it also is an enstatite diabase. In the slice a small rock fragment, about one-eighth of an inch in diameter, is enclosed. This at first sight seems to have a base of a speckled pale-brown glass, but that, on applying the nicols, proves to be really holocrystalline. In it are scattered some greenish-brown rods and flakes, probably altered pyroxene or biotite, with a rosette of chlorite and a few granules of iron-oxide. I suspect this to have been an andesite, caught up by the more basic rock and altered by heat.

"Shaft rock No. 19, 1,540-feet level." This is a dark-coloured basalt, very minutely speckled with lighter-coloured felspar, and containing a few grains of pyrite. The fragment is roughly five-sided, about 3½ inches across, and 1 inch at thickest. The s.g. is 3·033. Under the microscope the rock shows traces of a base of a pale-brownish colour, but this proves to be replaced by secondary microlithic products. In it the following minerals are thickly scattered: (*a*) plagioclase: a few moderate-sized, broken crystals, rather decomposed, are associated with grains of iron-oxide, and very many long lath-like clear crystallites, often in pairs, parted by a very thin wedge of the base; these are not seldom associated in rather divergent groups; (*b*) brownish augite, imperfectly idiomorphic, inclining to occur in clusters; (*c*) iron-oxide, in crystalline grains, granules, and rods, the second and third often associated to form knotty clubs, combs with sloping teeth, or (rarely) gratings. There are occasional grains of pyrite. The larger felspars certainly, the augite not improbably, represent an earlier stage in the history of the rock, which is a rather altered magma-basalt.

"Soft rock, 1,500-feet level, No. 17." This obviously differs much from all the others. It is an irregular fragment, not quite four inches long, of a rather light lilac-grey rock, mottled by dull-green spots, varying in shape and size. The s.g. is 2·667. The rock consists of a number of small lath-shaped felspars, with some rounded prisms and spots of a very pale-green mineral, which acts but feebly on polarized light, in a granular brownish-grey ground-mass, which appears to be crowded with tiny lath-like microliths and minute mineral specks. It breaks up, with crossed nicols, into irregular spots, with low polarization tints, like a devitrification structure. The above-named "dull-green spots" are filled-up cavities. The rock is *now a variety of* porphyrite.

3. *Sedimentary Rocks.*

"No. 7, Quartzite": a large angular fragment with subconchoidal fracture, of a darkish quartzite or hard grit, somewhat felspathic, bearing a general resemblance to that described on the last occasion.[1] It seemed needless to have this sliced.

"No. 9, north of dyke, 1,200-feet level."[2] A squarish block (about 4″ × 3″ × 2″) bounded by joint faces of a darkish-grey, fine-grained felspathic sandstone. Under the microscope we see subangular to rather angular quartz grains, seemingly set in a matrix of minute sericite-like flakes. This also suggests in places the former existence of grains, which occasionally show the remains of felspar. Some dark irregular spots (yellowish-white with reflected light) prove with a magnification of about 80 diameters (which this rock requires) to be aggregates of more or less translucent yellowish to brownish granules, perhaps hydrocarbons. There are a few small, rather rounded zircons, with other less important microliths. The quartz grains appear to have been slightly enlarged. I have no doubt the rock was once a quartz-felspar grit, but it has been somewhat altered, perhaps by heated water.

"North-east side of dyke, 1,200-feet level": a large fragment, smoothed on one side, of a fairly hard mudstone, in colour greenish-grey, somewhat banded with darker layers (not sliced).

"No. 4, Black Shale." This rock effervesces rather briskly with HCl, and is a dark, compact or minutely granular, non-laminated, calcareous mudstone, traversed by some very small veins of pyrite, possibly with slight traces of gold. In the hope of finding remains of organisms I had a slice prepared. The rock consists of roundish or subangular granules of variable size, speckled brown, separated by dark lines probably of carbonaceous matter. A few flakes of a mica, probably a bleached biotite, are also present. I cannot recognize any organisms, but one or two of the smaller grains exhibit a ring-like structure, recalling the form of certain spores. The grains generally show whitish to pinkish tints with crossed nicols, and I think are very probably a dolomitic calcite, mixed with earthy and carbonaceous matter. One or two small veins apparently are filled with the first mineral.

"No. 2, Limestone": a compact cream-coloured limestone. As the depth is not stated, I have not had it sliced, but I think it more likely to have been formed by precipitation than by true sedimentation, and to be from one of the tufaceous deposits said to occur in the upper part of the diamantiferous breccia.

"No. 6, Agate": a mass of chalcedony and quartz which has been formed in a cavity of a compact, rather decomposed basalt, or possibly basic andesite.

"Calcite": from a vein of calcite with abundant pyrite and possibly traces of copper, which apparently has traversed a darkish, rather hard shale.

[1] GEOLOGICAL MAGAZINE, 1895, p. 500.

[2] The 2 in 1,200 is damaged, and may be a higher figure.

4. *Conclusion.*

ieve, as I have already stated,[1] that the diamonds were not ed where they are now discovered, but, like the conspicuous , pyroxenes, mica, garnets, and iron-oxides, had their origin uch greater depth in the earth's crust. Thus I think it able that the carbon was obtained from the Karoo Shales. er words, I consider the diamonds, whatever may have been ast history, to have come from the crystalline floor[2] on these shales were deposited, or to be at any rate Pre-Triassic I see no reason why carbon should not be present in the magma, whether it afterwards crystallized in a peridotite ative iron.[3]

anic action probably began before the end of the Karoo as the great sheet of so-called melaphyre seems to be lated with its higher deposits,[4] and some of the dykes may be imately coeval with it. Afterwards (was it because of this trable cover of lava?) the pipes were formed, probably in t time, by a series of great explosions, caused by gases lated at considerable depth. These sent the outer part of ystalline floor, including the diamonds, as well as the ing Karoo shales, flying shattered into the air. Cones and may have been built up above these pipes, but I expect that, me of those in the Eifel, they were never high, and that the ed material mostly fell back, after a few explosions, into pes and filled them like the "necks" in Scotland. Then lcano, after some more lava had struggled to reach the surface ng, at any rate, the dykes in the necks), passed into a solfatara during which the numerous secondary changes mentioned were produced, the carbonates were deposited, and the minor re of the mass was obscured. Afterwards ordinary meteoric es began to work; water percolating from above still further d the mass, more especially in its upper parts, producing ellow ground" and the "soft blue" and depositing tufa.

result of this examination is to confirm me in my opinion that amantiferous rock—the so-called Kimberlite—is a volcanic a rather than a peculiar form of peridotite. While it is lt, owing to secondary changes, to demonstrate the fragmental ter of the matrix, I have failed to identify it with any form of tite (or serpentine) known to me, and I cannot understand

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OL. MAG. 1895, p. 501.

must be remembered that pyroxenite, troktolite, and gabbro are frequently sociated with peridotites and are generally intrusive in them.

at graphite, cliftonite, carbonado, and diamond occur in the native iron, is, of well known: see Fletcher, Min. Mag., vii, 121. Meteorites vary from pure native iron to peridotites: see Wadsworth, "Lithological Studies," and Crookes, *Nature*, lvi, p. 325. Native iron is well known to occur in salts.

ording to Sir W. Crookes, F.R.S., "The Diamond Mines of Kimberley" e at Imperial Institute), the section is as follows: (1) soil, (2) basalt, ecomposed, 20′-90′, (3) black shale (combustible), 200′-250′, (4) "mela-' about 400′, (5) quartzite, about 400,′ (6) variable shales.

how masses of that rock, the smallest of which is about 370 yards in diameter,[1] masses, of which one has been traced to a depth of 500 yards, could remain throughout in a practically uniform glassy condition.

P.S. — This paper was written before the publication of the notice of the late Professor Lewis' work (p. 366). On a few points, as will have been seen, I differ from its author, but need only refer to the following. Two are inaccuracies: on p. 367, line 6, for "original" read "unpublished," and line 13 for "three" read "two." There was no manuscript of Section III,. unless a few references could be thus called. A third is an error (p. 368): the largest inclusion in plate i is said to consist of rather decomposed compact serpentinized olivines and pyroxenes. This reads to me rather like nonsense, and I do not make the statement. I assert the fragment to be "a rather decomposed compact serpentinous rock." I now believe it is identical with some of the fragments described above. In regard to the "Hard Wack Floating Reef," which the writer apprehends may be the "Kimberlite proper," and laments that "no detailed examination" of this rock has been given, I need only remark that the slices used by Professor Lewis all represented the same *species* of rock, the difference among them being only varietal (none had descriptive labels); also that I strongly suspect I have examined a specimen of it, furnished to me by the late Professor A. H. Green (under a different name), and believe it to be nothing else than a more compact variety of the ordinary rock. I fail to understand the reviewer's remark about local writers and the shale on p. 368. So far as I remember, Professor Lewis nowhere asserts that the shale fragments are fused at the edges. A fragment of shale may be *altered* yet not *fused*. The perofskite I am disposed to consider generally, if not always, a secondary mineral.

IV.—NOTES ON THE GEOLOGY OF COUNTY WATERFORD.

1. THE FAUNA OF THE ORDOVICIAN BEDS NEAR TRAMORE.

By F. R. COWPER REED, M.A., F.G.S.

Introductory.

DURING an examination of the complicated series of Lower Palæozoic rocks in County Waterford, with which I am still engaged, I have had the opportunity of collecting largely from the few fossiliferous beds in the neighbourhood of Tramore, and a study of the fossils throws considerable light on the vexed question of their age. It is not my intention in this paper to discuss the relations of the igneous and sedimentary rocks, nor to attempt to explain the structure of the district. The palæontological evidence of the exact horizon of certain fossiliferous beds will here alone be sidered, with a view to establish a definite base-line which has viously been wanting in descriptions of these rocks. The conıng statement has frequently been made that a mixture of ndeilo and Bala fossils is found in these beds and elsewhere in land, and that the principles of classification followed in Great tain are not applicable. From my study of the literature on Lower Palæozoic of this part of Ireland, and from my investiions in the field and museums, I feel convinced that this startling nion is due partly to the erroneous identification of the fossils, tly to confusing fossils from distinct horizons, partly to the etition by folds, etc., of the same beds, and partly from misrehension of the distribution or vertical range of some species. ave given below a list of the literature containing references to fossiliferous and associated rocks of this district, but for the ve reasons we cannot unfortunately rely on the lists of fossils ich are said to occur in them, and I have consequently drawn conclusions only from specimens collected in the various ılities by myself or from those of identifiable horizons which ave personally examined.

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[1] The largest must be about 450 yards in diameter. Some of the necks in Scotland are considerably larger than this. See Sir A. Geikie's "Ancient Volcanoes of Great Britain," chs. xxv and xxxi.

21. Thomas Weaver, "On the Geological Relations of the East of Ireland": Trans. Geol. Soc., ser. I, vol. v, p. 117.
24. Rev. R. H. Ryland, "The History, Topography, and Antiquities of the County and City of Waterford." 8vo. London (*passim*).
33. J. Hodgson Holdsworth, "On the Geology of the District of the Knockmahon Mines": Journ. Geol. Soc. Dublin, vol. i, p. 85.
39. Sir R. Griffith, "On the Principle of Colouring adopted for the Geological Map of Ireland, etc.": Journ. Geol. Soc. Dublin, vol. ii, pt. 1, p. 78.
39. Major Austin, "A brief Notice of the Geology around the Shores of Waterford Haven": Proc. Geol. Soc., vol. iii, p. 154.
40. Th. Weaver, "On the Geological Relations of the South of Ireland": Trans. Geol. Soc., ser. II, vol. v, p. 1.
41. T. Austin, "Observations relative to the Elevation of Land on the Shores of Waterford Haven, etc.": Proc. Geol. Soc., vol. iii, p. 360.
41. J. Apjohn, Presidential Address: Journ. Geol. Soc. Dublin, vol. ii, p. 132.
43. General J. E. Portlock, Geol. Rep. Londonderry, pp. 262, 283, 292, etc.
44. Sir R. Griffith, "On certain Silurian Districts of Ireland": Rep. Brit. Assoc. Trans., p. 46.
44. H. N. Nevins, "Some Remarks on Three Localities of Silurian Fossils lately discovered in Co. Waterford": Journ. Geol. Soc. Dublin, vol. iii, p. 78.
44. "Localities of Silurian Fossils lately discovered in Waterford, Wexford, and Wicklow": Journ. Geol. Soc. Dublin, vol. iii, part 1, p. 57.

1845. Sir R. Griffith, "On the Order of Succession of the Strata of the South of Ireland": Journ. Geol. Soc. Dublin, vol. iii, p. 150.
1846. F. McCoy, "Synopsis of the Silurian Fossils of Ireland," pp. 7, 16, 26, etc.
1852. J. Beete Jukes, "Sketch of the Geology of the County of Waterford": Journ. Geol. Soc. Dublin, vol. v, p. 147.
1854. Sir R. Murchison, "Siluria," 1st ed., p. 166.
1856. J. Kelly, "Researches among the Palæozoic Rocks of Ireland": Journ. Geol. Soc. Dublin, vol. vii, p. 115.
1857. Sir R. Griffith, "Notes on the Stratigraphical Relations of the Rocks of the South of Ireland": Journ. Geol. Soc. Dublin, vol. viii, p. 7.
1859. J. Beete Jukes and Professor Haughton, "The Lower Palæozoic Rocks of the South-East of Ireland": Trans. Royal Irish Acad., vol. xxiii, p. 563.
1860. J. Kelly, "On the Graywacke Rocks of Ireland as compared with those of England": Journ. Geol. Soc. Dublin, vol. viii, pp. 2, 251.
1860. W. B. Brownrigg and Theo. Cooke, "Geological Description of the District extending from Dungarvan to Annestown, Co. Waterford": Journ. Geol. Soc. Dublin, vol. ix, p. 8.
1865. Memoir Geol. Surv. Ireland, Explan. Sheets 167, 168, etc.
1869. W. H. Baily, "Notes on Graptolites and Allied Fossils occurring in Ireland": Quart. Journ. Geol. Soc., vol. xxv, p. 158.
1872. Sir R. Murchison, "Siluria," 5th ed., p. 173 et seq.
1878. G. H. Kinahan, "The Geology of Ireland," p. 27.
1878. Prof. Hull, "Physical Geology and Geography of Ireland," p. 13.
1879. Prof. Ch. Lapworth, "Distribution of the Rhabdophora": Ann. Mag. Nat. Hist., ser. v, vol. iv, p. 424.
1891. Prof. Hull, "Physical Geology and Geography of Ireland," 2nd ed., p. 16.
1895. A. McHenry and W. W. Watts, "Guide to the Collection of Rocks and Fossils belonging to the Geological Survey of Ireland," pp. 82, 89, 90.
1897. Sir A. Geikie, "Ancient Volcanoes of Great Britain," vol. i, pp. 242–50.

Description of the Beds and their Fossil Contents.

The best preserved and most abundant fossils near Tramore occur in three principal sets of exposures, but the beds represented in those localities are by no means all on the same horizon.

1. Taking the localities in order from east to west, we begin with the most easterly ones in the townlands of Quillia and Castletown. On the one-inch Geological Survey Map, Sheet 179, there is marked in about a mile east of the Tramore-Waterford Railway a sinuous band of limestone. The rock consists of a greyish calcareous sandstone, weathering to a brownish-yellow colour, and containing a large

number of fossils. The exposure in the field south of the Castle in the townland of Castleton (locality 17 of the Survey Memoir, Explan. Sheets 167, 168, etc.) is in an old overgrown quarry in which the dip of the beds is still visible, and is marked on the map as 80° N.W. From this small exposure I obtained, with difficulty, the following fossils:—

Phacops Jamesi, Portl.
Orthis flabellulum, Sow.
O. crispa, McCoy
Phyllopora Hisingeri, McCoy
Stenopora fibrosa, Goldf.
S. (?) *lycoperdon*, Hall

All of these also occur in the far richer locality at Quillia, to be immediately mentioned, and in addition to the above there are recorded in the Survey Memoir the following species:—

Cheirurus bimucronatus, Murch.
Cybele verrucosa, Dalm.
Illænus Bowmani, Salt.
Orthis calligramma, Dalm.
Orthis elegantula, Dalm.
Plectambonites (*Leptæna*) *sericea*, Sow.
Rafinesquina expansa, Sow. (*Strophomena concentrica*)

The species of *Phacops* recorded in the Survey Memoir here and at Quillia as *Ph. Brongniarti* is really *Ph. Jamesi*, as I have determined by examination of the Survey specimens. I have not myself found nor recognized in any collection specimens of the true *Ph. Brongniarti* from these places.

At Quillia, about a mile south of the Castletown locality, this brown calcareous sandstone is exposed in the banks of a lane leading to a farm off the high road; it dips to the NNW. at about 50°. Its fauna is rich in individuals, but not particularly so in species. The following fossils I have collected at this spot:—

Asaphus gigas, De Kay
Cybele tramorensis, Reed
C. verrucosa, Dalm.
Phacops Jamesi, Portl.
Orthis calligramma, Dalm.
O. crispa, McCoy
O. elegantula, Dalm.
O. testudinaria, Dalm.
Rafinesquina expansa, Sow.
R. deltoidea, Conr.
Plectambonites sericea, Sow.
Caryocystites granatum, Forbes
Echinosphærites, sp. (?)
Glyptocrinus, sp. (?)
Stenopora fibrosa, Goldf.
Nebulipora lens, McCoy (?)

Of the above fossils *Phacops Jamesi* is by far the most abundant. *Plectambonites sericea* is also very plentiful. In the Dublin Museum there is from this spot a head-shield of *Cybele tramorensis*, a species which I described[1] from a solitary specimen found here by me in 1894. The Survey Memoir also mentions the following species from Quillia:—

Amphion pseudo-articulatus, Portl.
Calymene brevicapitata, Portl.
Orthoceras Brongniarti (?), Troost

The next locality for fossils lies on the west side of the Tramore-Waterford Railway, and the exposures occur on the hill in the townland of Pickardstown. It is sometimes spoken of as Drumcannon and corresponds to "locality 19" of the Survey Memoir.

There is more than one fossiliferous bed exposed on this hill, and the relations of the various beds are fairly plain. On the lower slopes of the east side of the hill occur black slates dipping N.W.

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[1] Geol. Mag., Dec. IV, Vol. II, 1895, p. 49, Pl. III, Fig. 1.

at about 50°; in these no fossils have as yet been found. They resemble in general character the great mass of highly folded unfossiliferous slates between this locality and Quillia. Above these slates comes a crushed calcareous flaggy sandstone (*a*) full of *Rafinesquina expansa*. In the quarry near Hammondville at the south end of the ridge the intrusive diabase is seen to be in contact with a greyish limestone, which is split up at this spot by thin shaly bands (*b*) containing very abundant Entomostraca. Thick bedded limestone (*c*) is found well exposed in a large quarry towards the north end of the ridge, and is the source of the majority of the fossils. It is a very tough bluish-grey rock when freshly broken, but weathers into a rotten brownish material. Perfect specimens are difficult to extract from it. It dips into the hill at about 45° N.W. and overlies the above-mentioned beds. Above it is a bedded felsite, which also can be traced sweeping round the northern end of the hill. In a lane at the north-west corner of the hill a sandy fossiliferous limestone is found dipping SSE. at about 60°, and containing *Orthis crispa*, *Rafinesquina expansa*, and *Stenopora fibrosa*. Thus we seem to have a synclinal existing in the hill. The diabase exposed in the southern quarry is found to cut obliquely across all the beds and is traceable to the northern end of the hill. The following fossils were collected by me from these beds:—

(a) *Phacops Jamesi*, Portl.
Orthis calligramma, Dalm., var.
Rafinesquina expansa, Sow.
Stenopora fibrosa, Goldf.

(b) *Agnostus agnostiformis*, McCoy
Encrinurus sexcostatus, Salt.
Harpes, sp.
Trinucleus concentricus, Eaton (?)
Primitia mundula, Jones
P. mundula var. *longa*, Jones
P. mundula var. *producta* (?), Jones[1]
Turrilepas, sp. (?)

(c) *Amphion pseudo-articulatus*, Portl.
Lichas, sp.
Phacops Jamesi, Portl.
Orthis calligramma, Dalm.
O. crispa, McCoy
Plectambonites sericea, Sow.
Plectambonites quinquecostata, McCoy
Conularia, sp.
Glyptocrinus, sp. (?)
Stenopora fibrosa, Goldf.
Nebulipora lens, McCoy (?)

In the Survey Memoir and Collection there are the following additional fossils from this locality:—

Asaphus gigas, De Kay
Cheirurus gelasinosus, Portl.
Cybele verrucosa, Dalm.
Rafinesquina deltoidea, Conr.
Palæaster obtusus, Forbes

It will be seen on comparison of the lists that the fauna is practically identical with that from Quillia. The slight difference in the fauna of the shaly beds here is to be attributed to the different character of the deposit and of the original physical conditions. The abundance of *Phacops Jamesi* is a noteworthy feature at both Quillia and Pickardstown.

2. South of Tramore there is exposed along the coast a series of fossiliferous beds belonging to different horizons in the Ordovician system. The lower beds consist of black or dark-grey calcareous slates, which dip at high angles below bedded sandy limestones

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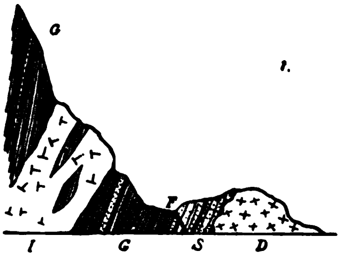
[1] Professor Rupert Jones has kindly examined and named the specimens of Entomostraca [illegible] beds.

ntaining nodular layers largely composed of *Stenopora* (?) *lyco- rdon.* The black slates are exposed on the foreshore, and mostly ly at low-water, between Tramore and Lady Elizabeth's Cove. e limestones form generally the base or whole face of the cliffs the intervals between the igneous rocks. Where the sequence beds is distinct, the black slates are found to become calcareous their upper portion and to pass into thin-bedded shaly limestones, ich are succeeded by the arenaceous nodular limestones, as may seen near Lady Elizabeth's Cove. North of Lady Doneraile's ve, however, and towards Tramore, the relations of these beds much confused by faulting, folding, and intrusions of igneous ks, and a fault-breccia frequently occurs along the line of their ction.

Fossils have not been found in the main mass of these slates; but the small cove nearly opposite Carrigaghalia and adjoining on the rth that cove called the "Ladies' bathing-place," there are seen in cliffs black soft fissile argillaceous slates, dipping at 80° WNW., ich in the Ladies' Cove are much pierced by igneous intrusions l contain graptolites (Fig. 1). Unfortunately their relation to arenaceous limestones of the cliffs north of Lady Elizabeth's ve is not here seen, but in lithological characters they may be npared with the much crushed black slates between Lady neraile's Cove and Tramore, in which, however, no fossils have t been found. These underlie the arenaceous limestones; and palæontological reasons, as will appear, we must consider the ptolitic slates of the Ladies' Bathing Cove also to belong to a atigraphical horizon immediately below the arenaceous limestones.

FIG. 1.—SECTION IN COVE OPPOSITE CARRIGAGHALIA.



G. Graptolitic black shales, with thin flags and calcareous bands.
S. Flags.
D. Intrusive diabase.
I. Intrusive andesitic dolerite, enclosing patches of G.
F. Fault.

The following graptolites were collected by me in the black slates the Ladies' Bathing Cove[1]:—

Climacograptus perexcavatus, Lapw.
Cryptograptus, sp.
Dicellograptus sextans, Hall (?)
Dicranograptus Nicholsoni, Hopk.
D. ramosus, Hall

[1] Miss G. Elles, of Newnham College, kindly identified these for me.

A spicule of a Lyssakine Hexactinellid sponge, kindly identified by Dr. Hinde, F.R.S., was also found by me in these beds.

All these graptolites occur in the Glenkiln Shales of Scotland; and in addition to the above there are in the Dublin Museum the following, labelled "Lady Elizabeth's Cove, Tramore," but contained in exactly identical black slates and probably from the same spot as my specimens. Mr. Clark, of the Geological Survey of Ireland, has kindly furnished me with the list of the species, and the specimens I have also examined myself:—

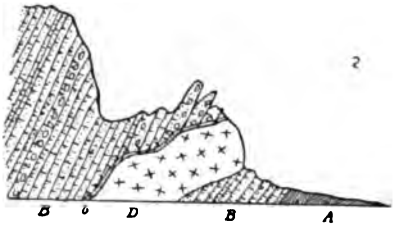
Climacograptus bicornis, Hall
Cœnograptus gracilis, Hall
Didymograptus, sp.
Dicellograptus, sp.
Dendrograptus, sp. (?)

In addition to the above, Professor Lapworth[1] quotes the following list of graptolites given by Baily,[2] from "dark shales in Tramore Bay":—

Climacograptus bicornis, Hall
Cœnograptus gracilis, Hall
Dicellograptus sextans, Hall
Dicranograptus ramosus, Hall
Didymograptus, sp.
Diplograptus foliaceus, Murch.

The whole assemblage is characteristic of the Glenkiln Shales, and we can therefore have no hesitation in ascribing the black slates which I have mentioned to that horizon. The list of graptolites given in the Survey Memoir of this district from the same locality (designated "locality 21") is misleading, owing to the incorrect determination of the species. No Ordovician beds older than these graptolitic shales have so far been proved to exist in this district.

FIG. 2.—SECTION IN CLIFFS, WEST SIDE OF TRAMORE BAY.



A. Black calcareous slates on foreshore.
B. Sandy impure and nodular limestones.
D. Intrusive diabase.
b. Crushed beds at junction.

The next beds to be described are the impure limestones which immediately overlie the graptolitic beds. These arenaceous and nodular limestones, which are so prominently developed along the coast from Tramore to Newtown Cove, contain in bands here and there a large number of fossils, which are, however, difficult to extract in anything but a fragmentary condition. The beds dip at angles from 45° to 70° to the WNW., but the average angle is about 60°. (Fig. 2.) I have collected the following fossils from them :—

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[1] Lapworth, Ann. Mag. Nat. Hist., ser. 5, vol. iv, 1879, p. 424.
[2] Baily, Q.J.G.S., vol. xxv, 1869, p. 158.

Calymene Blumenbachi, Brong.
C. brevicapitata, Portl.
Cybele, sp.
Phacops Jamesi, Portl.
Orthis calligramma, Dalm.
Plectambonites sericea, Sow.
Rafinesquina deltoidea, Conr.
Stenopora fibrosa, Goldf.
S. (?) *lycoperdon*, Hall

In the Survey Memoir it appears that the fossils from "locality 20" come principally from the sandy limestones; but a slight uncertainty prevails on this point, since on p. 19 of the Memoir the beds are described as "grey calcareous slates," while on p. 28 they are called "compact bluish limestones" and "brown shaly beds." The Newtown Cove fossils are also included in the description, but they come from beds which are stratigraphically rather higher and have a somewhat different faunistic facies, though a few species are common to them and the sandy limestones. The following fossils in the Survey and other collections seem to come from these sandy limestones :—

Ampyx mammillatus, Sars.
Asaphus gigas, De Kay
Calymene brevicapitata, Portl.
Cybele verrucosa, Dalm.
Encrinurus sexcostatus, Salt.
Illænus Bowmani, Salt. (?)
Lichas, sp.
Phacops Jamesi, Portl.
P. truncato-caudatus, Portl.
Remopleurides Colbii, Portl. (?)
Trinucleus seticornis, His., var. (?)
Phyllopora Hisingeri, McCoy
Ptilodictya dichotoma, Portl.
Porambonites intercedens, Pand.
Plectambonites sericea, Sow.
Orthis biforata, Schloth.
O. crispa, McCoy
O. elegantula, Dalm.
Rafinesquina deltoidea, Conr.
R. expansa, Sow.
Cyrtoceras (?) *inæquiseptum*, Portl.
Conularia, sp.
Glyptocrinus, sp.

If the foregoing lists are compared with those of the fossils from Pickardstown and Quillia, no important differences are apparent, except in the relative abundance of some forms such as *Phacops Jamesi*, which is rare near Tramore, while extraordinarily abundant at the other localities. This might be due to the less calcareous character of the Tramore beds rather than to any difference in the age of the strata, but the occurrence of the forms *Ampyx mammillatus* and *Remopleurides Colbii* may indicate a slightly higher horizon, since these genera are so prevalent in the overlying Newtown Cove beds, and are absent at Pickardstown, etc. Moreover, since the Tramore beds pass up into the Newtown Cove beds, whereas at Pickardstown a felsite immediately overlies the fossiliferous beds, it is probable that the latter correspond only with the lower part of the coastal series. Black slates underlie the calcareous fossiliferous beds in both localities, and there is no reason to doubt that they are of the same age, though palæontological evidence is, so far, unfortunately wanting. The correspondence in the faunas of the Tramore, Pickardstown, and Quillia rocks is so great that it seems impossible to do otherwise than group them together in the same *assise*; the dissimilarity in the bionomic conditions which is indicated by the difference in the lithological character of the rocks and succession at each locality, appears sufficient to account for the slight modification in the relative abundance of some species and for the appearance of some new forms. The Newtown Cove beds have a somewhat different fauna, and must be considered separately.

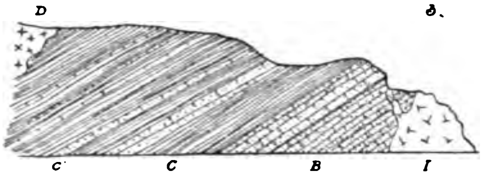
The correlation of these impure limestones is not difficult when we remember that they immediately succeed beds containing a Glenkiln fauna. If we look at the succession in the South of Scotland, we see the Balcletchie beds with a somewhat similar fauna containing Hartfell graptolites, and the Hartfell Shales immediately succeeding the Glenkiln Shales. Additional evidence is afforded by the fact that some fossils of the Tramore limestones are only known in Great Britain from the Balcletchie and associated beds (*Asaphus gigas, Cheirurus gelasinosus, Porambonites intercedens*), while one species (*Asaphus gigas*) is absolutely peculiar to the Balcletchie beds.

Certain species of the Tramore limestones are, however, peculiar, and have not so far been found outside Ireland:—

Amphion pseudo-articulatus.
Cybele tramorensis.
Phacops Jamesi.
Phacops truncato-caudatus.
Palæaster obtusus.

This may be partly due to the fact that Ireland belonged to a different but adjoining zoological province, and partly that the Tramore limestones are not exactly on the same horizon as the Balcletchie beds. The latter suggestion is rendered all the more probable from the much closer correspondence of the fauna of the overlying Newtown Cove beds with that of the Balcletchie beds. I would therefore consider the Tramore limestones as corresponding with only the lower portion of the Balcletchie beds of Scotland, and with the whole or some portion of the underlying Benan conglomerate.

FIG. 3.—SECTION AT NEWTOWN COVE.



B. Sandy impure limestones.
C. Dark calcareous shales with fossils.
C'. Greenish calcareous shales and mudstones with thin limestone bands, weathering yellowish-brown.
D. Intrusive diabase.
I. Intrusive andesitic dolerite.

3. These Newtown Cove beds are found immediately above the impure limestones of the cliffs, and are well seen in the sides of the

ng down to Newtown Cove, near the Metal Man, Tramore
The lowest beds there exposed consist of blackish cal-
ates weathering a dark rusty-brown, and they are overlain
ey and greenish soft calcareous shales and mudstones with
re limestones, which decay into a very soft yellowish or
n rock. The uppermost beds are dark argillaceous slates.
dip at 40° W., and in the section exposed in the road-
Newtown Cove, they are succeeded by an andesitic
pparently intrusive. Fossils are very abundant in these
I have myself collected the following species :—

wer beds (*C*, dark calcareous shales).

evicapitata, Portl.
).
.sp.
cosa, Dalm.
ni, Portl.
si, Portl.
ngniarti, Portl.
Portl. (?)
es dorsospinifer, Portl.

R. platyceps, McCoy
Trinucleus concentricus, Eaton (?)
Primitia mundula var. *producta*, Jones
Orbiculoidea, sp.
Orthis crispa, McCoy
Plectambonites quinquecostata, McCoy
P. sericea, Sow.
Echinosphærites arachnoideus, Forbes (?)

eds, in which trilobites are by far the most abundant
th in species and individuals, pass up imperceptibly into
ore fossiliferous overlying calcareous shales and mudstones.
contain the following species, all of which I have per-
llected :—

er beds (*C′*, calcareous mudstones, etc.).

ostiformis, McCoy
millatus, Sars.
s, Dalm. (? = *A. rostratus*,

s, De Kay.
us, McCoy (?)
, Portl.
ortlocki, Salt.
p.
menbachi, Brong.
,, var.
asinosus, Portl.
p.
cosa, Dalm.
n.sp.
excostatus, Salt., var.
ni, Portl.

mani, Salt.

Lichas hibernicus, Portl. (?)
Phacops Brongniarti, Portl.
P. truncato-caudatus, Portl.
Remopleurides Colbii, Portl.
R. dorsospinifer, Portl.
R. laterispinifer, Portl.
R. platyceps, McCoy
Trinucleus concentricus, Eaton (?)
T. hibernicus, Reed
Primitia, sp.
Turrilepas cf. *scotica*, Nich. and Eth.
Orthis calligramma, Dalm.
O. crispa, McCoy
O. elegantula, Dalm., var. *parva*
Plectambonites quinquecostata, McCoy
P. sericea, Sow.
Helminthochiton Griffithi, Salt.
Glyptocystites cf. *Logani*, Billings
Crinoid stems.

a remarkable assemblage of fossils and is specially com-
th that in the Balcletchie Shales. The trilobites also in
nd (*b*) are very similar to those found in the Ordovician
irnaskea, in Tyrone,[1] in which the following Newtown
ls are said to occur :—

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[1] Mem. Geol. Surv. Ireland, Sheet 34 (1878), p. 25.

Ampyx rostratus, Sars.
Asaphus gigas.
Calymene brevicapitata.
Cybele verrucosa.
Harpes Dorani.
Illænus Bowmani.
Lichas hibernicus.
Remopleurides Colbii.
Trinucleus concentricus.
Orthis calligramma.
Plectambonites sericea.

The prominent feature of the fauna at Tirnaskea, as at Newtown Cove, is the trilobites, but the almost complete absence of mollusca at the latter place is a striking difference.

It is the Balcletchie fauna which bears the closest resemblance. Messrs. Nicholson and Etheridge[1] record the following Newtown Cove species from the Balcletchie beds:—

Agnostus agnostiformis.
Asaphus gigas.
Cheirurus gelasinosus.
Cybele verrucosa.
Illænus Bowmani.
Lichas hibernicus.
Phacops Brongniarti.
Remopleurides laterispinifer.
Turrilepas scotica.

Several species of *Ampyx* are also recorded.

Professor Lapworth[2] mentions the following species from the Balcletchie beds, all of which occur at Newtown Cove:—

Asaphus gigas.
Phacops Brongniarti.
Remopleurides dorsospinifer.
Orthis calligramma.
Plectambonites quinquecostata.
P. sericea.

The genus *Barrandia*, which seems confined to the Lower Bala, is also mentioned. Of special importance do I consider the occurrence of the restricted species *Asaphus gigas* and *Cheirurus gelasinosus.* The former species is only found in America in the homotaxial Hudson River beds and the Trenton Limestone. *Glyptocystites Logani*[3] is also a Trenton Limestone species. The occurrence of some peculiar species (*Harpes Dorani, H. Flanagani, Barrandia Portlocki, Remopleurides platyceps, Trinucleus hibernicus*) gives the fauna the usual special Irish stamp.

The presence of typical Lower Bala species and genera, and the very close affinity of the fauna to that of the Balcletchie beds, demonstrate unmistakably the horizon of the Newtown Cove beds; and the palæontological evidence is found to be confirmed by the stratigraphical as shown in the field.

The succession, therefore, of the fossiliferous beds near Tramore is as follows:—

(4) Shales, mudstones, and impure limestones of Newtown Cove (=greater portion of the Balcletchie Beds).
(3) Impure sandy limestones of Tramore Bay cliffs, including towards the base the Quillia and Pickardstown beds (=lower portion of the Balcletchie Beds and portion of the Benan Conglomerate).
(2) Black slates of Carrigaghalia, etc. (=Glenkiln Shales).
(1) Unfossiliferous dark slates.

The fauna and succession of the beds at Newtown Head, near Passage, will be described on a subsequent occasion, as well as the other fossiliferous Ordovician beds in County Waterford.

[1] Mon. Girv. Silur. Foss., 1879, pp. 228-9.
[2] Q.J.G.S., vol. xxxviii, 1882, p. 586.
[3] Billings, Canad. Organ. Rem., 1858, dec. iii, p. 57, pl. iv, fig. 1.

NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE SECTION C (GEOLOGY), BRITISH ASSOCIATION, TORONTO, 1897.

I.—PRELIMINARY NOTICE OF SOME EXPERIMENTS ON THE FLOW OF ROCKS.—By FRANK D. ADAMS and JOHN T. NICHOLSON, McGill University, Montreal.

THESE experiments aim at ascertaining whether it is possible, by subjecting rocks artificially to pressure under the conditions which obtain in the deeper parts of the earth's crust, to produce in them the deformation and cataclastic structures exhibited by the folded rocks of the interior of mountain ranges or of the older formations of the earth.

Three factors contribute toward bringing about the conditions to which rocks are subjected in the deeper parts of the earth's crust: (1) great pressure from every direction; (2) high temperatures; (3) action of percolating waters. In the present experiments the attempt has been made to reproduce only the first of these conditions; in subsequent experiments the endeavour will be made to reproduce all three of them.

The experiments have been made chiefly with pure Carrara marble. Columns of the marble, 2 centimetres and 2½ centimetres in diameter and about 4 centimetres in length, were very accurately turned and polished. Heavy wrought-iron tubes were then made, imitating the plan adopted in the construction of ordnance, by rolling long strips of Swedish iron around a bar of soft wrought iron, and welding the strips to the bar as they were rolled around it. The core of soft iron composing the bar was then drilled out, leaving a tube of welded Swedish iron 6 millimetres thick, so constructed that the fibres of the iron run around the tube, instead of being parallel to its length. This tube was then very accurately fitted on to the column of marble. This was accomplished by giving a very slight taper to both the column and the interior of the tube, and so arranging it that the marble would pass only about half-way into the tube when cold. The tube was then expanded by heating, so as to allow the marble to pass completely into it, and leave about 3 centimetres of the tube free at either end. On allowing the tube to cool, a perfect contact between the iron and marble was obtained, and it was no longer possible to withdraw the latter. Any very slight failure to fit at any point, if such a failure existed in any case, was rendered harmless by the fact that under a comparatively low pressure the limestone is found to be sufficiently elastic, not only to fill up any such minute space, but even to stretch the tube, and, on the pressure being relieved, to contract again to its original form, so that it will drop out of the tube which has been thus enlarged. Into either end of the tube containing the small column an accurately fitting sliding steel plug was inserted, and by means of these the marble was submitted to a pressure far above that which would be sufficient to crush it if not so inclosed. The machine employed in obtaining the pressure was so arranged that the pressure might be maintained for weeks, or even months, if required. Under these circumstances, the conditions of pressure to which the marble is subjected are those in the "zone of flow" of the earth's crust—those, namely, of a pressure above that of its elastic limit, while yet unable to break in the ordinary manner, owing to the tube which confines it having a still higher elastic limit. Under the pressure, which was applied gradually and in some cases continued for several weeks, the tube was found to slowly bulge until a very marked enlargement of the portion surrounding the marble had taken place. The tube was then cut through longitudinally by means of a milling machine along two lines opposite one another.

The marble within, however, was still firm, and held the respective sides of the iron tube, now completely separated, so tightly together that it was impossible without mechanical aids to tear these apart. By means of a wedge, however, they could be separated, splitting the marble through longitudinally. The column in one experiment was reduced from 40 millimetres to 21 millimetres in height. The deformed marble differs from the original rock in having a dead white colour, the glistening cleavage faces of calcite being no longer visible, and although not so hard as the original rock, it is still firm and compact, and especially so when its deformation has been carried out very slowly. No accurate measurements as to its strength have yet been made, but it will withstand a sharp blow, and fragments of it, weighing 10 grams, have been allowed to fall through a height of over 2½ metres (8 feet) on to a wooden platform, from which it rebounded without breaking. Thin sections of the deformed marble, when examined under the microscope, show that the calcite individuals composing the rock have in many cases been twisted and flattened, and in the majority of cases a very fine polysynthetic pressure-twinning has been induced in them, with movement along gliding planes, as well as several other structures seen in nature in highly deformed rocks.

The experiments therefore show that limestone, even when dry and at ordinary temperatures, does possess a certain degree of plasticity, and can be made to "flow," the movements set up developing many structures which are characteristic of rocks which have been squeezed or folded in the deeper portions of our earth's crust.

II.—The Glaciation of North-Central Canada. By J. B. Tyrrell.

IN the region immediately west of Hudson Bay the earliest glaciation of which any traces were recognized, flowed outwards from a gathering-ground which lay north or north-west of Doobaunt Lake. Subsequently this gathering-ground moved south-eastward, until it centred over the country between Doobaunt and Yath-kyed Lakes. From one or other of these centres the ice seems, to the writer, to have flowed westward and south-westward to within a short distance of the base of the Rocky Mountains; southward, for more than 1,600 miles to the States of Iowa and Illinois; eastward into the basin of Hudson Bay; and northward into the Arctic Ocean.

No evidence was discovered of any great elevation of this central area in Glacial or immediately Pre-Glacial times, and, in the absence of such evidence, it would seem not improbable that the land then stood at about the same height above the sea as it stands at present. In this case, the moisture giving rise to the immense precipitation of snow would have been derived from the adjacent waters of Hudson Bay and the Arctic Ocean.

The name Keewatin glacier has been applied to this central continental ice-sheet. In general character it appears to have been somewhat similar to the great glacier of North-Western Europe, with a centre lying near the sea-coast, a steep and short slope seaward, and a very much longer and more gentle slope towards the interior of the continent. But there was this difference between the two, that the centre of the latter was over a high rocky country, from which the ice naturally flowed outwards towards the surrounding lower country; while the centre of the former was over what is now, and was probably also then, a low-lying plain, on which the snow accumulated to such depths as to cause it to flow over country very considerably higher.

After the Keewatin glacier had reached its full extent, it began gradually to decrease in size. As it disappeared from the Northern States and the North-West Territories of Canada, it left a series of moraines, many of which can be readily traced across the unwooded country as ridges of rounded stony hills. While retiring down gradually descending slopes, many temporary extra-glacial lakes were formed in front of it, and were drained one after another as it retired to still lower country. Before it had withdrawn from the Winnipeg basin, it was joined by an advancing glacier from the east, and, in front of the two, Lake Agassiz, one of the largest of the extra-glacial lakes, was formed.

In its final stages the general gathering-ground of the Keewatin glacier seems to have moved still farther eastward, or nearer to the coast of Hudson Bay, and to have broken into several separate centres, one of which lay over the country south-east of Yath-kyed Lake, while another was probably located north of the head of Chesterfield Inlet.

After the retirement of the Keewatin glacier the land in the vicinity of Hudson Bay stood from 500 to 600 feet below its present level, and gradually rose to its present height.

III.—GLACIAL AND INTERGLACIAL DEPOSITS AT TORONTO. By

Professor A. P. COLEMAN, Ph.D., Toronto University.

THE ravines of the river Don at Toronto and the lake cliffs of Scarborough Heights, a few miles to the east, provide exceedingly interesting sections of the drift, from 100 to 350 feet in thickness, displaying three or more sheets of till and a varying number of interglacial beds.

The most important section, at Taylor's brickyard in the Don Valley, shows a lowest till overlying Cambro-Silurian shale of Hudson River age. Upon this rest 18 feet of sand and clay, containing many unios and other shells, as well as leaves and pieces of wood. Some of the unios do not now live in Canadian waters, but are found in the Mississippi; and several species of trees now belonging to the States to the south occur with them, indicating a climate decidedly warmer than the present. Above this come stratified clay and sand, with a caribou horn and remains of insects and plants belonging to a colder climate than the present. This set of clays and sands is best shown at Scarborough, where the series rises 148 feet above Lake Ontario, and contains many species of extinct beetles, as well as shells of mollusca, mosses, and wood of hardy trees.

A complicated middle till overlies these beds, which were deeply eroded before the advance of the ice. Another less important fossil-bearing interglacial bed occurs above the middle till at elevations up to 240 feet above the lake, and is followed by a third till. Great changes in the level of the water occurred in connection with these climatic changes, the lake being much lower than at present before the first glacial advance and after the first interglacial time. During the deposition of the middle till, and also while the last sheet of till was being deposited, the water stood from 250 to 300 feet above the present level of the lake, which stands 247 feet above the sea. The retreat of the last ice-sheet was followed by the Iroquois episode, leaving a well-marked elevated beach. The length of time required for the first interglacial period is probably to be estimated at thousands of years; and during this time, at the beginning of which the climate was very warm, the ice-sheet of the Laurentide glacier must have completely disappeared. The correlation of the series of events described with those of the drift of the United States and of Europe is difficult, but probably the chief interglacial period corresponds to Jas. Geikie's Neudeckian, or the interval between the Iowan and Wisconsin glacial advances.

IV.—ON THE STRUCTURE AND ORIGIN OF CERTAIN ROCKS OF THE LAURENTIAN SYSTEM. By FRANK D. ADAMS, Ph.D., F.R.S.C., McGill University, Montreal.

THE paper presents the results of recent and somewhat extended studies of several areas of the Laurentian of Canada, and deals more particularly with the origin of certain members of this system as indicated by their structure or composition. While it is impossible in the present state of our knowledge to arrive at any definite conclusions concerning the origin of many, or perhaps even of the majority, of the rocks composing the Laurentian, the origin of certain members of the system can be determined. Some of these, although now possessing a more or less distinct and even highly pronounced foliation or stratiform appearance, can be proved to be igneous or intrusive rocks, while it can be shown that others are of aqueous origin.

To the former class belong the anorthosites and many of the orthoclase gneisses. These rocks, although frequently distinctly foliated, can in many places be traced into perfectly massive varieties, and form great intrusions, interrupting and cutting off the older members of the system. The foliation and stratiform appearance, which led the older geologists to class them as altered sediments, is due to movements induced by pressure, and they show protoclastic or cataclastic structure in great perfection.

To the aqueous rocks, on the other hand, belong the crystalline limestones and certain gneisses usually associated with them. These rocks not only differ in structure from those above referred to, but have a chemical composition not possessed by any igneous rock. The cataclastic structures are very subordinate, and the rocks are characterized by a very extensive recrystallization, accompanied by the development of new minerals.

It may therefore be said, without going beyond that which the facts warrant, that there are in the Laurentian at least two distinct sets of foliated rocks. One of these, comprising the limestones, some quartzites, and certain garnetiferous or sillimanite gneisses, represents, in all probability, highly altered and extremely ancient sediments. The other set, intimately associated with these, is of igneous origin, and comprises numerous and very extensive intrusions, both acid and basic in character, which were probably injected at widely separated times. Those masses which were first intruded, and have been subjected to all the subsequent squeezing and metamorphism, are now represented by well-defined and apparently interstratified augen-gneisses and granulites; others, intruded at later periods, though showing the effects of pressure, retain more or less of their massive character; while still others, which have been injected since all movements ceased, are recognized by all as undoubted igneous intrusions.

REVIEWS.

I.—INTERNATIONAL GEOLOGICAL CONGRESS.—Congrès Géologique International. Compte-Rendu de la Sixième Session, en Suisse. 8vo; pp. xii, 710, with Supplement (Table of Strata). Lausanne, April, 1897.

THE Sixth Session of the International Geological Congress was held at Zurich in 1894, and just before the Seventh Session was held at St. Petersburg, nearly three years after date, the volume of 1894 proceedings was issued. Like the previous volumes published by the Congress, the present work contains a miscellaneous series of discussions, reports, and original papers on various geological subjects, together with records of excursions. Most of the articles are in French, but some are in German, and others in English; and among the subjects dealt with are Ontogeny and Phyllogeny, the structure of gneisses and gabbro, New Zealand glaciers, the geology of Arabia and Palestine, Alpine geology. Contact metamorphism, and Quaternary and Tertiary classification.

Perhaps the most important article is that by Professor Renevier entitled "Chronographe Géologique," being an explanatory statement to accompany a second edition of his "Tableau des Terrains Sedimentaires," which originally appeared in 1873–4 in the *Bulletin de la Société vaudoise des sciences naturelles*, vol. xii, and is now issued as a supplement to the volume before us. This Table is printed on coloured papers, the colours for each geological system corresponding with those adopted on the Geological Map of Europe in course of publication by the Congress. The Table is an elaborate and comprehensive one. In it are indicated the prominent biological zones in each stage, and also the various types of deposit, organic and detrital, and the conditions under which they were accumulated, from the Abyssal to the Aerial, in the principal localities where they have been recognized. The author has received help from many geologists, especially from Karpinsky in reference to Carboniferous, from Kayser in reference to Devonian, and from Lapworth with regard to Silurian. The Table is not put forward as the authoritative scheme of the Congress; it is essentially an independent work; but the author's hope is, that it will serve as a basis for an international Table of Formations constructed essentially on chronological grounds. In his explanatory remarks he gives much information on the history and usages of various terms, and adds a "Repertoire Stratigraphique" or glossary of terms applied to different divisions of strata in various parts of the globe. On these matters he invites criticism and correction, and without doubt he will have no reason to complain that they are wanting.

In treating of the geology of the globe where peat and blown sand have been formed in one area while radiolarian ooze was being slowly accumulated in another, we certainly require other terms than those of Norwich Crag, Kimeridge Clay, or May Hill Sandstone. The general biological and physical history of the globe must in the main be an indoor study to the individuals who attempt to deal with so vast a subject, for they must gather the materials from the detailed observations of the many local workers. The question is, how far can the local workers adopt the general terms now proposed, and at the same time make known the results of their labours in terms that would be locally applicable and intelligible. Formations are restricted to certain areas, and their time-limits vary not only in different countries but within varying geographical limits in one region. Without local names, of course, the stratigraphy of a district can never be clearly explained. Were the terms adopted by Renevier to come into use, the Middle and part of our Lower Lias would be *Pliensbachian*, our New Red Marl would be *Juvavian*, the Spilsby Sandstone would be *Berriasian*, the Atherfield Clay *Barremian*, the Bracklesham Beds *Lutetian*, and the Coralline Crag *Plaisancian*. In some cases our formations would fairly correspond with the time-limits implied by the general terms; in other cases our formations would represent but a portion of an age, or belong to more than one age. Such difficulties in the way of general correlation are well understood and recognized by all geologists; and if a universal scheme be adopted, then the local formations of each country can perhaps be referred to as Tremadoc Beds (Potsdamian), Magnesian Limestone (Thuringian), or Inferior Oolite (Bajocian), without implying more than an approximate correlation. It must be borne in mind that serious differences exist with regard to the time-limits that should be indicated by some of the terms such as Bajocian. Even in the volume before us we find instances of divergent views. Mr. Warren Upham would, and we think rightly, employ the term Quaternary for Pleistocene, and Holocene or Recent. Renevier places Quaternary as a synonym of Pleistocene. Moreover, the classification of Tertiary strata proposed by Sacco (p. 230) differs in several important particulars from that given by Renevier.

We would protest against the use of such vague terms as Pre-Pliocene, Supra-Lias, and Infra-Lias for epochs or series; even such names as Malm and Dogger for Jurassic divisions are objectionable in a universal table of strata, for both terms in this country are locally applied in very different senses. It is not in accordance with custom and decidedly awkward to place the Lias in the Jurassic series and yet to put it below *Jurassique Inférieur*! Mr. Jukes-Browne may have something to say in regard to the grouping of Albian, Vraconian, and Rotomagian in the Middle Cretaceous or Cenomanian. That there is plenty of room for criticism in this Table of Strata, will be admitted; and certainly all will not agree with the placing of Arvonian as a subdivision of Laurentian, and with the assignment to it of the "problematic organism" *Eozoon Canadense*!

Despite these objections, we feel grateful to Professor Renevier for the great labour he has bestowed on a most important though vexatious subject, and for thus preparing the way for some settled and more definite chronological nomenclature. H. B. W.

II.—Geological Survey of Canada. Geological and Topographical Map of the Northern Part of the Lake of the Woods and Adjacent Country. Scale, two miles to one inch. (April, 1897.)

THIS region was geologically surveyed by A. C. Lawson; see Report CC, Annual Reports, New Series, vol. i, 1885; A. P. Coleman has furnished information on some points. The map has been compiled and drawn by A. E. Barlow (1885) and W. J. Wilson (1897). The sources of information are given in a marginal note.

Three parallel geological NW.-SE. sections are given, on approximately the same scale as the map, traversing the country north and south of the Lake, two near its western and one at its eastern end. The Index for the Formations refers to:—I. Huronian (Keewatin), comprising (1) Hydromicaceous and nacreous schists, with some associated chloritic and micaceous schists, and including areas of altered quartz-porphyry. (2) Clay-slate, mica-schist, and quartzite, with some fine-grained gneiss. (3) Agglomerates and other coarse clastic rocks, all more or less schistose, and generally of volcanic origin. (4) Hornblende-schists and altered traps, with some chlorite-schists, of volcanic origin. II. Laurentian. (5) Coarse-grained gneiss. III. Irruptive. (6) Later irruptive basic rocks. (7) Felsite, micro-granite, quartz-porphyry. (8) Granite.

Ten marginal notes afford particulars about these formations, and on other local points. The first two groups of schists, slate, gneiss, etc., are more or less *auriferous*, with many promising veins.

III.—Geological Survey of Canada, 1897. Geological Map of part of the Trail Creek, Mining Division, West Kootenay District, British Columbia. Scale, one mile to one inch. Geologically surveyed by R. G. McConnell. Preliminary edition.

THE Map, with contours, was compiled and drawn by J. McEvoy, from original surveys and plans of railways and the Department of Lands and Works, British Columbia. The series of rock-formations indicated on the map are: — (1) Conglomerate (Tertiary?). (2) Palæozoic volcanic rocks, effusive and fragmental. (3) Altered basic igneous rocks (serpentine, etc.). (4) Gabbro. (5) Schists and granite-gneisses (Shuswap series?). (6) Younger granite. (7) Older granite.

Each of these rock-groups has a marginal note descriptive of characteristics, area, etc. Notes "8" and "9" refer more particularly to the *auriferous* rocks, thus:—

Note 8. "The sulphide ores of the district are associated principally with the basic igneous rocks, and especially with the central gabbro area, around which the principal mines, so far worked, are grouped. The veins have an approximately east-and-west strike, and, with few exceptions, dip to the north at high angles. They follow lines of fissuring; and, so far as present evidence goes, belong to the class known as 'replacement veins.' The lodes are somewhat irregular, and vary in size from small stringers and disseminated grains to great ore-bodies, forty feet or more in width. The principal ores are pyrrhotite and chalcopyrite, often associated with pyrite and mispickel and occasionally with molybdenite. Cobaltiferous mispickel, or danaite, occurs at the 'Evening Star,' and gersdorffite, a sulph-arsenide of nickel, at the same mine, and at the 'Columbia-Kootenay.' Besides the above minerals, galena and blende occur in some of the mines situated near the outskirts of the main mineral area. The ores are often more or less siliceous, and calcspar is occasionally met with in seams and pockets; but, as a rule, the principal gangue is the ordinary country-rock of the district, usually only slightly altered. The gold contents of the ores are exceedingly variable, ranging from traces up to several ounces per ton. The smelter-returns of 1,200 tons of 'Le Roi' first-class ore are given by Mr. Carlyle as 2·6 oz. of gold, 1·8 oz. of silver, and 2·5 per cent. of copper; and of 4,800 tons second-class ore as 1·34 oz. of gold, 1·4 oz. of silver, and 1·6 per cent. copper."

Note 9. "Fissure veins filled with a quartz gangue are occasionally met with in this district. The best known of these is the 'O.K.' mine, situated west of Sheep Creek, but a number of locations have also been made on Murphy Creek, Grouse Mountain, and other places. The veins vary in size from a few inches to six feet or more, and carry free gold and auriferous sulphides of iron, copper, and lead."

The index to the numbers of the mining claims comprises 240, 457, 459, 531, and on to 1,692, with some exceptions.

IV.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), vol. viii, Reports A, D, J, L, R, S, for 1895. With numerous plates and maps. 8vo. (Ottawa: Dawson, 1897.)

THE Summary Report (A, 154 pages) of the Geological Survey Department, by the Director, treats of the progress and work done in explorations and surveys, and in the museum, library, and office generally, during 1895.

In Report D (117 pages, with a map and three plates), J. B. Tyrrell and D. B. Dowling describe the country between Athabasca Lake and Churchill River, treating of the Laurentian, Huronian, Cambrian, Cretaceous, and Pleistocene rocks, with the physical geography of the region, especially along the several routes.

Report J (184 pages, with two maps and eleven plates, besides nine smaller figures), by Frank D. Adams, is a very interesting résumé of what is known of the geology and economic resources of that portion of the Laurentian region lying north of the Island of Montreal. The earlier observations by Logan and others are carefully recorded, and the co-operation of colleagues is fully acknowledged. The following general statement (p. 10), regarding the Archæan rocks here treated of, is important:—

"That portion of the area occupied by the Archæan is underlain for the most part by a series of gneisses, presenting great variations in both structure and composition, and with which are associated crystalline limestones, quartzites, etc. These belong to the 'Grenville Series' of Sir William Logan,[1] and are of Laurentian age. In certain parts of the area, however, there are great stretches of orthoclase-gneiss, much more uniform in character, and without limestones and quartzites. These are referable, in some cases at least, to the 'Fundamental Gneiss' of Logan, which was by him believed to underlie the Grenville Series, and to form the basal member of the Laurentian system.

"Breaking through these gneisses, and in some cases interbanded or interstratified with them, are several anorthosite masses, by far the largest of these being that which for purposes of convenience may be termed the 'Morin anorthosite,' and which comprises an area of 990 square miles. Two important intrusions of acid rocks, one of granite and the other of syenite, also occur in the district.

"In the present Report the anorthosites are shown to be intrusions, and are separated from the Laurentian proper. The name 'Laurentian' is therefore made to embrace the Fundamental Gneiss, which, although, so far as can be ascertained at present, essentially igneous in origin, may possibly contain sedimentary material, and the Grenville Series, which is composed of altered sediments, associated with much injected igneous matter."

I.—The Laurentian gneisses and their associated rocks are described stratigraphically and petrographically (pp. 11, etc.). The Grenville Series of banded, foliated, and faulted gneisses, and the associated crystalline limestone, quartzite, garnet-rock, intrusive syenite, and apparently deep-seated granite, are described in detail. The gneisses are divisible into (1) those of igneous origin (pp. 38, etc.); (2) those of sedimentary origin (pp. 49, etc.) with limestones and quartzites; and (3) some gneisses of doubtful origin (pp. 67, etc.).

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[1] "Geology of Canada," 1863, p. 839.

II.—Of the Anorthosite groups, that of the Morin area is first described (pp. 85, etc.), as to its stratigraphy and petrology. It varies in its constituents and structure, the latter frequently showing the results of pressure and movement. At page 115 we read:—

"It would thus seem that the clastic structure described as occurring in these anorthosites occupies, in a way, a position intermediate between the 'protoclastic structure' of Brögger and the cataclastic structure commonly observed in sheared rocks.

"In the Morin area, then, we have a great intrusive mass of anorthosite, or gabbro very rich in plagioclase, breaking through the Laurentian, cutting off successive horizons, including portions of the gneiss, sending an apophysis into it, and in some places bounded by a zone of rock which exhibits many characteristics of a contact-product. This mass in most places shows irregularities in size of grain, and in some places a streaked or irregularly banded structure, while in one part of the above-mentioned apophysis it is well foliated, which foliated structure there is reason to believe is a secondary one. It certainly does not represent a partially obliterated bedding, as the earlier observers seem to have believed, while the other supposed evidences of the existence of a great overlying sedimentary series, of which it was supposed to form part, are also wanting; the gneiss and limestone with which it was thought to be interstratified really belonging to the Grenville Series, while the apparent interstratification of the anorthosite is due to intrusion.

"The whole is furthermore unconformably overlain by flat unaltered strata of Potsdam and Calciferous age, and thus possessed in Cambrian times the characters which it now presents; while the nature of the anorthosite, and its relation to the Laurentian, lead us to suppose that it is much nearer in age to the latter than to the overlying Cambro-Silurian, probably not much more recent than the Grenville Series itself."

Other anorthosite masses, in seven distinct areas, are then described (pp. 116, etc.), accompanied by a table of analyses of various plagioclasic or anorthositic rocks, together with notes of the occurrence of such rocks in Norway, Russia, Egypt, and the United States. Post-Archæan dykes are described at pp. 134, etc. This Report also comprises valuable notes (pp. 139, etc.) on the economic materials of the region, including iron-ores, graphite, apatite, mica, "infusorial" (!)—probably diatomaceous—earth (used locally for whitewashing buildings), garnet-rock,[1] limestone, marble, and anorthosite (some used for paving-stone).

Report L, by A. P. Low (387 pages, including seven appendices, with four plates and four maps), is on explorations in the Labrador

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[1] The hybrid and therefore very improper word "garnetiferous" is used throughout this Report, wherever "garnet-bearing" could and should have been used.

Peninsula along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers, in 1892–5. Mention is made of the sources of information about the history, physical geography, and natural history of the region explored; acknowledgment is made of kind help and hospitality given by officers of the Hudson Bay Company; and the work of colleagues and assistants is carefully recorded. The elaborate chronological account of previous discoveries and explorations (pp. 7–19) is of great interest; it extends from 990 to 1891. The physical geography, climate, soil, trees and other plants, the population, and fisheries, are successively dealt with. Detailed descriptions of the routes explored follow (pp. 56–195). The observations by Mr. Low and the Assistant Surveyors on the geological structure of the great territory under notice were made along widely separated lines of exploration, but afford the means of making an approximate estimate of the distribution and extent of the areas of the different rocks, their mutual relationship, modes of occurrence, and relative age; also of their economic materials, and of the features and conditions of surface due to glacial action (pp. 195–311).

"The term 'Laurentian' is employed to designate the complex mass of highly crystalline Archæan rocks of which the greater part of the Labrador Peninsula is composed. These do not differ in any essential particulars from those similarly designated in other parts of Canada. They consist chiefly of gneisses and schists, some of which are believed to be highly metamorphosed materials of clastic origin, while others are regarded as foliated eruptives. As it is not possible, except in limited areas, to separate these rocks on the map, they are necessarily treated together. . . . . Under the name 'Huronian' are included several widely separated areas of clastic and volcanic rocks, together with many basic eruptives; these are represented by various schists, conglomerates, breccias, diorites, and other rocks more or less interfolded with the Laurentian.

"The Cambrian rocks rest unconformably upon the Laurentian and Huronian, and are made up of bedded sandstones, argillites, shales, and limestones, along with bedded traps and other basic intrusive and volcanic rocks. . . . .

"The Laurentian and Huronian gneisses and schists are intensely folded. This folding took place long previous to the deposition of the sedimentary beds of Cambrian age; and a sufficiently long time had elapsed between the period of folding and the Cambrian submergence to allow for great removals of material by denudation, and for the main sculpturing of the Peninsula. . . . . The enormous lapse of time requisite for the formation of the Hamilton inlet and river-valley can hardly be conceived if the denudation was not much greater than that under present conditions."

We may note that "the anorthosite is a variety of gabbro, made up of labradorite, holding isolated masses of hypersthene or rhombic pyroxene, ilmenite, and mica. In texture it varies from exceedingly coarse, with crystalline faces sometimes nine by six inches, to a fine-grained saccharoidal form. The colour is generally a shade of violet, and is mostly dark, especially in the coarser varieties, which sometimes have a green tinge. The fine-grained variety is always light-coloured, varying from white to light shades of pink and violet. Along the north shore of Michikamau Lake, where the rock is very coarse-grained, many of the crystal faces show a beautiful iridescent play of colour, in shades of green, blue, and bronze-yellow" (p. 230). This *precious labradorite* is again mentioned at page 289.

Appendix I, by A. P. Low, consists of a scientific list of the Mammalia of Labrador; Appendix II, of the birds; III, of the principal food fishes; IV, of the Insects, by Dr. James Fletcher. Appendix V contains Mr. W. Ferrier's notes on the microscopic structure of thirty-four rocks from Labrador; Appendix VI is an elaborate tabular and classified catalogue by J. M. Macoun of the known plants of Labrador; Appendix VII is D. V. Eaton's Meteorological Observations in the Peninsula in 1893–5.

Report R, by Dr. G. Ch. Hoffman and his Assistants, F. G. Wait and R. A. A. Johnston, exhibits such portion of the work carried out in the Laboratory of the Survey as is of special or general interest. It contains among other matter references to several interesting and some valuable minerals new to Canada, as Hessite, Petzite, Stromeyerite, Bismite, and Smithsonite.

Lastly, the Annual Report for 1895, for Mineral Statistics and Mines, by E. D. Ingall and L. L. Brophy, 1896. The Mineral Production of Canada for 1894 is valued at 20,950,000 dollars; and for 1895 at 22,000,000 dollars; the increase being due chiefly to copper, gold, lead, platinum, and silver. Some comparative, diagrammatic tables, showing the relative production of asbestos, coal, iron, phosphate, gold, and salt, for a series of years, enhance the value of the numerous numerical tables relating to these and other mineral products. A good Index, as usual, completes the volume of reports.

T. R. J.

V.—First Annual Report of the Geological Commission of the Cape of Good Hope for 1896. (Cape Town, 1897.)

THE First Annual Report of the Geological Commission of Cape Colony, now to hand, will be welcomed by all interested in South African Geology.

At present the staff is very small, consisting only of three members. There are two Assistant Geologists, Messrs. A. W. Rogers and E. H. L. Schwarz, while Dr. Corstorphine gives his partial services as Geologist.

Besides the record of field-work for 1896, the Report includes an account of the Cango Caves, and reports on the Laingsburg Coal, and of the subcommittee on deep artesian well-borings. The publication of the Geological Map of the area so far surveyed, on the scale of 800 Cape roods to the inch (half an inch to the mile), with detailed accounts of the work done, will be looked forward to with interest.

During the year 1896 large portions of the following districts have been mapped by Messrs. Rogers and Schwarz: Cape, Stellenbosch, Malmesbury, Paarl, Tulbagh, Ceres, Worcester, Caledon, and Beaufort West.

In the south-west districts Mr. Rogers proves conclusively the unconformity of the Table Mountain Sandstone on the Malmesbury beds. In the Caledon district he confirms the reading of Mr. Bain that the beds marked as Malmesbury on Dunn's map (1887) are in reality of Bokkeveld (Devonian) age.

The sedimentary rocks around Beaufort West are all ascribed by Mr. Schwarz to the Karoo beds, and not to the Stormberg, as Dunn formerly supposed. The intrusive dolerites in the Karoo beds of Beaufort West are considered to be similar to the Palisade traps of New Jersey and New York.

The most important geological results are those that have been obtained during the present survey of the Tulbagh, Worcester, and Prince Albert districts. At Worcester a very large exposure of Ecca beds is described in contact with Malmesbury beds, a fault being suggested by Mr. Schwarz for this unusual relationship.

This confirmation of older observers of the existence of Karoo beds outside the prescribed limits of the Karoo Basin will be a surprise to many who are wedded to the idea of the simplicity in structure of South African geology. But a complete revolution in the reading of South African stratigraphy will startle no one personally acquainted with its present unsatisfactory state. In the area examined so far, the conformity of the Dwyka conglomerate and Zwartebergen group is agreed upon. This view is in direct opposition to that of the late Professor Green, but accords with the diagram section of the Prince Albert region by Mr. Sawyer.[1]

The theory of the glacial origin of the Dwyka conglomerate receives the support of the Commission, further evidence, in the shape of scratched stones, being brought forward.

Brief notes on the complicated regions of the Witzenbergen, Schurftenbergen, Hex River Mountains, and Langebergen, are supplied by Mr. Schwarz. The strata, from the Table Mountain Sandstone to the Ecca, are considered as being arranged in three main systems of folds conforming to the S-shaped curve.

Between the Schurftenbergen and Hex River Mountains the mass of the Zwartebergen beds is described as being thrust southwards, and many complexities of structure are hinted at. Again, near Verkeerde Vley the Zwartebergen group is said to be faulted against Table Mountain Sandstone, while north of the Gydo Mountains, in the Ceres district, the top of the Dwyka is faulted against the base of the Zwartebergen group.

This description of faulting, folding, and juxtaposition of rocks of various ages betokens a highly complicated region, and it is to be hoped that it will be examined in the greatest possible detail.

W. Gibson.

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[1] Report upon the Geology and Mineral Resources of the Division of Prince Albert and surrounding district, by A. R. Sawyer, Capetown, 1893.

CORRESPONDENCE.

FRESH-WATER OSTRACODS IN THE LOWER CARBONIFEROUS SERIES OF AYRSHIRE.

Sir.—On Friday last I found a bed of fresh-water Ostracoda in the strata exposed in the Gurdy cutting of the railway from Giffen to Kilbirnie.

The beds exposed are as follows:—

	ft.	ins.
Highest *marine* limestone seen in the cutting.		
Black shale, tough	1	8
Dark shale	0	8
Dark shale crowded with fresh-water Ostracoda	0	9
Dark shale	1	6
Sandstone with *Stigmaria*	3	6
Thick bed of dark shale with abundance of *marine* fossils.		
Limestone with *marine* fossils.		

Many of the Ostracoda are filled with *pyrites*, but the valves are *calcareous*; and they often fall off when touched with the point of a needle. The carapaces are usually white, giving the shale a sandy appearance; sometimes they are brown. They occur mostly as single valves.

I believe this is the first time that fresh-water Ostracoda have been found in connection with the marine limestones of Ayrshire. The position of the beds is in the upper part of the Lower Carboniferous Limestone Series of Ayrshire.

Mr. Robert Craig has described the strata of the Gurdy cutting in the Trans. Geol. Soc. Glasgow, vol. ix, p. 64. J. Smith.

Monkredding Kilwinning, *Sept.* 20, 1897.

TRINUCLEUS SETICORNIS.

Sir,—Mr. Marr's letter requires a final answer. When a fossil is not recorded from a certain horizon it is naturally believed that it has really not been found on that horizon. It is almost needless to say that when subsequent research proves an earlier statement to be wrong we consider that the author of it made an unavoidable mistake — unavoidable because of the imperfect knowledge of that time, but a mistake nevertheless in the light of present knowledge. Such mistakes must, of course, be frequent in the progress of any science, particularly in the case of the range of fossils. With regard to the range of the species in question, I have declined to be drawn into an argument, because I find several distinct forms are included under this name by different authors. F. R. Cowper Reed.

Cambridge, *October* 4, 1897.

A QUESTION OF NOMENCLATURE: CHEMICAL NAME FOR H_2O.

Sir,—In writing of the volatile constituents of an igneous magma, paste, or lava, of which the gas of H_2O forms the greater and most important part, I do not know what term should be used in ordinary parlance, as such words as water, water-gas, steam, vapour, simply imply definite physical states of H_2O. Now in a lava under moderate pressure H_2O may exist as steam in the form of bubbles

scattered through it, but under a sufficiently high pressure i
dissolved in the paste or magma, and then it is neither st
vapour, or water, though frequently spoken of as such. It se
to me that we have no reason to consider it otherwise than
oxide of hydrogen, and that we should speak and write of *Hydr*
oxide or Hydric oxide dissolved in the magma. Up to the pre
I have got over the difficulty by writing and speaking of it as E
but such gives me the feeling of looking pedantic on pape
sounding queer in words. I should be grateful, therefore, for
expression of opinion as to why *Hydric oxide* would not do, and
suggestion for a better term. H. J. JOHNSTON-LAVI

BEAULIEU, A.-M., FRANCE, *Sept.* 29, 1897.

OBITUARY.

JAMES WINDOES, OF CHIPPING NORTON.

BORN 1839. DIED SEPT. 26, 1897.

WE regret to record the death, at the age of 58, of the enthusi
collector of fossils, James Windoes. Born at Woodstock in 1
he settled in Chipping Norton some thirty years ago, during
whole of which time he was employed in the glove manufac
of Messrs. B. Bowen and Son. From childhood he manife
a great interest in fossils, but having no advantages of educat
he had to pursue his studies entirely unaided. All his spare t
was devoted to the search after and study of fossils, and prob
no man living had a minuter knowledge of the strata and t
organic remains in this part of Oxfordshire. Although of
exceedingly retiring disposition, yet he was always pleased
show his collection to anyone interested in it. Probably
people in Chipping Norton were aware that in a cottage in All
Street could be seen a collection of fossils and antiquities, uni
in its way; but Mr. Windoes was well known to the late Profe
Phillips and Mr. T. Beesley, as well as to Mr. Hudleston, Mr. E
Walford, and others, who have acknowledged the valuable assist
rendered by him.

When the railway was constructed between Banbury
Cheltenham, Mr. Windoes obtained a fine series of fossils f
the junction-beds of the Lower and Middle Lias. The specin
of *Cypricardia intermedia* were exceptionally well preserved. Ag
at Hook Norton in the Upper Lias, and at Chipping Norto
various divisions of the Inferior and Great Oolites, he worked l
and zealously, obtaining many fossils, and notably fine example
Trigonia signata from the Inferior Oolite of Heythrop. Ano
species obtained from this formation was named *Trigonia Wind*
by Dr. Lycett.

Notwithstanding his somewhat humble circumstances,
Windoes could not be induced to dispose of any of his dupli
fossils otherwise than by gift or exchange. The present wr
(who is indebted for some of the above particulars to the *Banb*
Guardian of September 30) well remembers the difficulty he
first had in procuring some specimens for the Museum of Pract

Geology, but an exchange was ultimately arranged by means of Geological Survey publications and some recent specimens of *Trigonia*, which latter especially gave great joy to Mr. Windoes. He was a true lover of Nature, worthy to rank with Robert Dick, of Thurso, and others, who, by patient industry and with little or no local encouragement, have rendered good service to geological science. H. B. W.

MISCELLANEOUS.

GEOLOGICAL SURVEY.—We regret to learn that Mr. W. W. Watts, M.A., F.G.S., who joined the staff of the Geological Survey in 1891, has just resigned his position of "Temporary Assistant Geologist." The experience which he brought to the Survey from his intimate acquaintance with the Lower Palæozoic and Igneous rocks of Shropshire and the Welsh borders, the subsequent large acquaintance which he made with the Igneous and Sedimentary rocks of Ireland, and with the fine Rock-collection in the Museum at Jermyn Street; his detailed examination of rocks from many areas in England and Wales, and his special study of the older rocks of Charnwood Forest, combined to give him a knowledge that must have been invaluable to the Survey. His loss to the Service is deplorable on this account alone, to say nothing of his readiness at all times to give advice and assistance to others. Mr. Watts has now become Assistant Professor of Geology at the Mason College, Birmingham, where he will have a fine field for work in co-operation with Professor Lapworth.

ON THE POSSIBLE IDENTITY OF *BENNETTITES*, *WILLIAMSONIA*, AND *ZAMITES GIGAS*.—Mr. A. C. Seward, M.A., F.G.S., brings forward evidence[1] in support of the organic connection between *Williamsonia* and the Cycadean fronds known as *Zamites gigas*, L. and H., and in favour of the close relationship, if not identity, of Carruthers' genera *Bennettites* and *Williamsonia*. In the earliest descriptions of the Jurassic inflorescence known as *Williamsonia*, Williamson and other authors regarded the genus as the fructification of the plant which bore the leaves known as *Zamites gigas*. In 1875 Saporta expressed himself strongly against the generally accepted view as to the union of *Williamsonia* and *Zamites*. A recent examination of a series of specimens in the Paris Natural History Museum and elsewhere has convinced the author that *Williamsonia* and *Zamites gigas* are parts of the same plant. Evidence had been previously brought forward of the practical identity of *Williamsonia* and *Bennettites*. More recently acquired information leads to the conclusion that we are now familiar, not only with the nature of the Bennettitian type of inflorescence, but also with the character of the fronds which were, in some instances, associated with this Jurassic fructification. In view of the facts before us, it is advisable that the generic name *Williamsonia* should be substituted for the provisional and comprehensive term *Zamites* as the more suitable generic name of Lindley and Hutton's species *Zamites gigas*.

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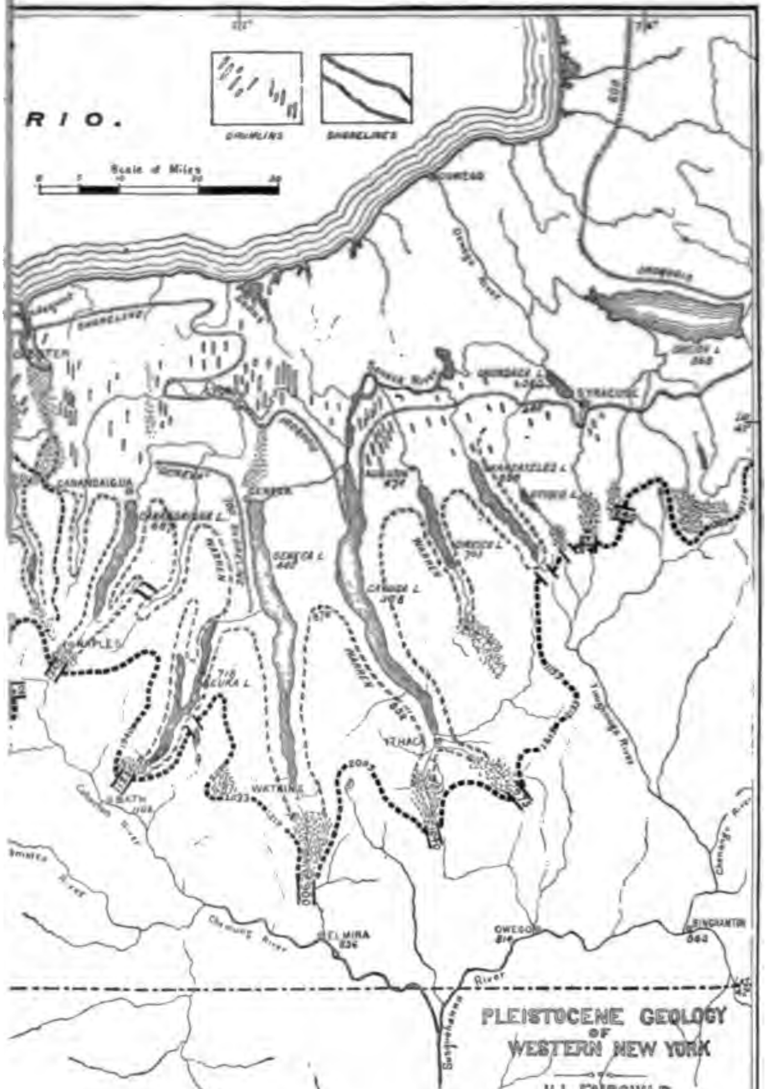
[1] Brit. Assoc. Meeting, Toronto, 1897: Sect. C (Geology).


RIO.
DRUMLINS
SHORELINES
Scale of Miles
0
5
10
20
30
SHORELINE
ONEIDA
Oswego River
Seneca River
ONONDAGA L.
SYRACUSE
CANANDAIGUA
CANANDAIGUA L.
GENEVA
SENECA L.
CAYUGA L.
SKANEATELES L.
OTISCO L.
OWASCO L.
WARREN
NAPLES
KEUKA L.
718
BATH
1108
WATKINS
ITHACA
ELMIRA
856
OWEGO
814
BINGHAMTON
843
Chemung River
Susquehanna River
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Chenango River
77°
76°
PLEISTOCENE GEOLOGY
OF
WESTERN NEW YORK
H.L. FAIRCHILD

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE IV. VOL. IV.

No. XII.—DECEMBER, 1897.

ORIGINAL ARTICLES.

I. — Glacial Geology of Western New York.[1]

By Professor Herman Le Roy Fairchild, B.Sc.,
Secretary of the Geological Society of America.

(WITH A MAP, PLATE XXI.)

Table of Contents.

Physical Features: Stratigraphy, Topography, Hydrography, and Pre-Glacial Topography and Drainage.
Ice Invasion: Directions of Flow and Thickness of Ice-cap.
Glacial Deposits: General Drift Sheet, Drumlins, Moraines.
Glacio-Aqueous Deposits: Eskers, Kames.
Glacial Lakes: Primitive and Smaller Local Lakes; Larger Local Lakes; Pre-Laurentian Lakes—Lake Warren, Lake (unnamed; Geneva Beach), Lake Iroquois.
Morainal Lakes. Channels of Glacial Drainage. Post-Glacial Stream Erosion.

Physical Features.

Stratigraphy.

THE area herein described is that part of New York State lying south of Lake Ontario, and west of longitude 76°. The dimensions of the area are, approximately, 95 miles north and south and 155 miles east and west, or nearly 15,000 square miles. The rocks[2] are shales, sandstones, and limestones of the Upper Silurian and Devonian systems. The strike is nearly east and west, with a southward dip averaging perhaps 50 feet to the mile. The limestones are contained almost entirely in the lower strata and outcrop in the northern belt, where the surface has the lower altitude. The more arenaceous rocks form the elevated plateau of the middle and southern belts.

Topography.

The present surface configuration is a complex result of several agencies, which may be succinctly grouped as follows:—

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[1] A paper read at the Toronto Meeting of the British Association, August, 1897.

[2] The stratigraphy is fully described in Dr. James Hall's Report, "Natural History of New York": Report on the Fourth Geological District, by James Hall. Albany, 1850.

1. Pre-Glacial subaerial erosion, probably effective since the close of the Palæozoic, and acting upon nearly horizontal strata of varying composition and resistance.

2. Glacial corrasion and transportation, supplemented both in the advance and retreat of the ice-sheet by the distributing and levelling action of glacial and morainal lakes.

3. The present brief period of renewed atmospheric and stream erosion.

The northern one-fourth of the area, forming a belt 25 miles wide along the south shore of Lake Ontario, was more deeply eroded by the Pre-Glacial agencies, as it contained all the limestones and the softer shales. It also suffered the greatest modification by the Glacial and lacustrine forces. It now forms a plain rising from about 300 feet elevation above tide near Lake Ontario to 600–700 feet at the distance of 25 miles south.

Southward the surface of the country rapidly rises into an elevated but irregular plateau, formed of the more enduring arenaceous strata, deeply gashed by stream erosion. The higher remnants of the plateau have an elevation considerably over 2,000 feet. The remarkable series of lakes known as the "Finger Lakes" occupy old stream-valleys along the northern border of this plateau.

Hydrography.

The waters of this area contribute to three great river systems. The greater part of the area is drained into the St. Lawrence, chiefly by the Genesee and the Oswego rivers, into Lake Ontario, only a minor tract draining into Lake Erie. The south-west corner of the State is drained by the Alleghany river into the Ohio-Mississippi, while the south-east part of the area is drained by the Susquehanna. The waters of the Mohawk-Hudson and of the Delaware lie beyond our eastern boundary.

The Genesee river is the only present stream which traverses the whole breadth of the State. Having its origin in Pennsylvania, it carries the line of water-parting between the Laurentian and the south-flowing waters beyond the southern limits of the State, and separates the Ohio-Mississippi and the Susquehanna drainage districts.

Few lakes occur in the streams of southern drainage. Excepting Chautauqua Lake, in the extreme south-west corner of the State, they are of insignificant size, and are all of glacial or morainal origin, and lie in cols or near the divide.

The series of large parallel lakes referred to above, lie along the north slope of the high plateau, and occupy ancient, deep river-valleys, whose channels have been partially blocked by drift, and further basined by the northward differential uplift of the region in Post-Glacial time.

Pre-Glacial Topography and Drainage.

The glacial and glacio-lacustrine agencies did not, it is believed, materially change the larger features of surface relief. Their effect is seen chiefly upon the minor topography, as a smoothing of saliencies, the rubbing of ridges into drumlinoid forms, and depositing of drift in the valleys. In general they have had a subduing effect, a smoothing-down and levelling-up action. The greatest effect of these forces was doubtless felt along the north-facing slope, or over the northern quarter of the area. The series of east-and-west escarpments which probably once existed here have been so destroyed that only a few traces remain. The greater glacial lakes were also restricted to this lower ground, and they have completed the levelling process.

In Pre-Glacial time, as now, the region was low upon the north, and the Hamilton and Portage-Chemung terranes formed a high plateau in the central and southern belts. It seems sure that the present northward drainage is following in general its Pre-Glacial direction, save that over the low northern plain the channels of stream-flow are all new.

The chief problem of the ancient drainage relates to that south of the present east-and-west divide. This water-parting between Laurentian and south-flowing waters is probably of glacial origin, due to morainal filling of old valleys. A partial study of the problem leads to the belief that the entire area of Western New York, with considerable territory of Northern Pennsylvania, was originally drained to the northward. The Genesee river system, flowing north entirely across the State, is suggestive of the Pre-Glacial condition of river-flow. In this connection it should be noted that the crustal warping of the region has been a relative uplift to the northward in Post-Glacial time, which has discouraged the northward flow.[1]

ICE INVASION.

Directions of Flow.

Of the direction of ice-movement during the period of advance and culmination of the glacial sheet, little evidence has been collected in this region. The trend of the terminal moraine, making a re-entrant and nearly right angle at Salamanca, indicates a general movement from the north-east, with a movement from the north-west along the basin of Lake Erie.[2]

The directions of movement of the waning ice-sheet are abundantly shown by striæ and drumlin ridges. The only portion of the area where the later ice-flow was from north-east to south-west, in general, is in the district between the Genesee and Niagara rivers. East of the Genesee the movement was south and east of south. Over this district the ice seems to have been compelled to flow in the direction of the deep valleys now holding the "Finger" lakes. In the south-west portion of the State the movement was away from the Lake Erie basin, or toward the south-east.

The comparatively abrupt change in direction in the neighbourhood of Rochester is noteworthy. The direction of striæ at Rochester is

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[1] A map showing the directions of drainage and the water-partings may be found in Bull. Geol. Soc. Amer., vol. vi, pl. xviii.

[2] See papers by Professor T. C. Chamberlin in the 3rd and 6th Annual Reports of the United States Geological Survey.

S. 45–60 W., and the drumlins are generally pointing south-west. Ten miles east of Rochester the drumlins are due north and south, and further away they veer to east of south. The depression of Irondequoit bay and valley is the dividing-line.

At the last recessional phase the ice over Rochester was given a southward and spreading movement, due probably to a re-entrant angle in the ice-body over the Irondequoit depression, where the ice was more rapidly removed by the deep glacial waters. This produced the crescentric moraine with which the Pinnacle Hills are correlated.[1]

Thickness of Ice-cap.

If we locate the margin of the ice-sheet at the terminal moraine, and assume the average slope of the surface to be 30 feet per mile for over 100 miles from the margin, the elevation of the ice-surface above tide-level is estimated as follows: over the eastern end of Lake Erie, 2,800 feet; at Buffalo, 3,000 feet; at Rochester, 4,000 feet; at the centre of Lake Ontario, 5,000 feet; at Syracuse, 5,500 feet; over the middle of Seneca Lake, 4,200 feet.

The thickness of the ice over the same localities is estimated, taking account of land altitude, and making allowance of three feet per mile for north-eastward differential uplift, as follows: over the eastern end of Lake Erie, 2,300 feet; at Buffalo, 2,400 feet; at Rochester, 3,700 feet; at the centre of Lake Ontario, 5,700 feet; at Syracuse, 5,400 feet; over the middle of Seneca Lake, 4,600 feet.

GLACIAL DEPOSITS.

General Drift Sheet.

On account of the variety, in kind and resistance, of the subjacent rock strata, the Glacial Drift is very variable in both amount and composition. It is usually thin upon the outcrop of hard strata, and in any locality consists largely of material derived from rocks lying immediately northward. For the bulk of material the distance of transportation is not great.

Drumlins.

This area includes some most remarkable groups of drumlins. Over some districts the great bulk of drift seems to be gathered into drumlin forms. The district between Rochester and Syracuse is especially noticeable, as here the drumlins are more conspicuous, rising abruptly from a level silt plain. In some places the drumlins coalesce into great and elevated masses, as for example the "Turk Hill" group, 12 miles south-east of Rochester. The typical form of the region is not the short, mound-like or ovoid form, although these are present, but much elongated or attenuated forms. A length of one mile is common. They seem to have the boldest forms and are more typical where containing more adhesive or clayey material, as along the belt of soft Salina shales. They are strangely wanting over large districts. Their direction, that of the ice-flow, has been referred to above. It is believed that they are subglacial constructional forms, a modification and localization of the ground-moraine. Every gradation can be found from a slight parallel ridging of the general drift surface (finely shown along the Rome, Watertown, and Ogdensburg Railroad, between Rochester and Niagara) to the bold isolated mound. Between the typical, strong, well-developed ridges (as in the neighbourhood of Clyde), there may often be found another set of minor ridges, as distinct as the great ridges, but perhaps of only a comparatively few feet in height and breadth.

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[1] H. L. Fairchild, "The Kame Moraine at Rochester, New York": American Geologist, vol. xvi, pp. 39-51.

Moraines.

The terminal moraine barely enters the southern edge of the State, at Olean and Salamanca, in a re-entrant angle. This line of drift is mapped in all large treatises and textbooks. The greatest development of morainal drift in the eastern half of our area fills the heads or southern ends of the valleys of the lake region, making an irregular and curving belt. This has been well illustrated by Professor Chamberlin.[1] In the larger north and south valleys of the "Finger" lake region, the moraine is usually an enormous drift mass of characteristic topography which blocks the valley and establishes the water-parting. Upon the high intervening ridges the moraine is inconspicuous or quite wanting. It seems evident that in the lake district the ice-field was, during recession, divided into practically distinct valley glaciers.

In the western and south-western portion of the area the moraines are more numerous and irregular lines. Two systems exist: one north-east and south-west, parallel with Lake Erie, in the south-west corner of the State; the other somewhat parallel with the Ontario shore, in the north-west corner of the State. These have been mapped by Mr. Frank Leverett.[2]

In the districts of well-developed drumlins morainal drift is almost wanting, but large kame areas suggest pauses of the ice-front. It would appear that the forces producing drumlins and moraines have not both been fully effective in the same locality. They seem in some degree mutually exclusive.

GLACIO-AQUEOUS DEPOSITS.

Eskers.

These linear masses of gravel and sand, deposited in the beds of overloaded subglacial streams, are not common. Those seen lie in the bottom of valleys. A very large one, though not of great length, is situated in the Irondequoit valley, near Pittsford.[3] Other well-defined eskers have been seen by the writer between Palmyra and Marion, Wayne Co.; near Gorham, Ontario Co.; in Henrietta Town,

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[1] "Terminal Moraine of the Second Glacial Epoch": 3rd Annual Report, U.S. Geol. Surv., pp. 291–492. Plate xxxiii covers the area of Western New York.

[2] Amer. Journ. Sci., vol. L, pp. 1–20.

[3] See Journal of Geology, vol. iv, p. 135.

Monroe Co. With fuller observation the list will doubtless be much extended. However, it would seem that the glacial streams in this area were seldom overloaded, although the large kame areas prove that they carried heavy burdens.

Kames.

While eskers are rare, kames are abundant, and some of immense development. This might be expected; for, if the glacial streams did not leave their loads in their channels, they must have dropped them at their debouchure.

In the great amount of sand and gravel, especially abundant and widespread north of the water-parting, it is hard to discriminate between true kame and other forms of water-laid drift, and no complete study has been made. A few of the very large and conspicuous kame areas have been briefly described by the writer.[1]

These large deposits all lie in the basins of glacial lakes, and it is suggested as a working hypothesis that true kames are formed only in static waters.

GLACIAL LAKES.

Primitive and Smaller Local Lakes.

As the ice-front crept slowly backward from the water-parting which its morainal drift had established, hundreds of lakelets were produced between the ice-foot and the northward-facing land-slopes. Most of these were evanescent, and have left slight traces. Others at the heads of well-defined valleys enlarged with the ice retreat, and existed long enough to produce definite outlet channels and the characteristic phenomena of static waters, excepting beaches, which require great breadth and depth of water.

Larger Local Lakes.

The large north-sloping valleys were the loci of greater glacial lakes. The life-history of these waters is often complicated and always fascinating. Each of the lakes in Western New York has been preceded by a vastly larger and deeper lake having its outlet to the southward. Large glacial lakes also existed in some valleys in which no water is ponded to-day. Some of these lakes have already been described.[2]

The most complicated and interesting lake-history belongs to the Genesee valley,[3] in which not less than ten stages of the glacial waters can be recognized. These waters flowed alternately east or west, according as the ice-sheet uncovered lower passes, and at different times they contributed to the Ohio-Mississippi, to the Susquehanna, to the Lake Michigan-Mississippi, and to the Mohawk-Hudson.

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[1] H. L. Fairchild, "Kame Areas in Western New York, South of Irondequoit and Sodus Bays": Journal of Geology, vol. iv, pp. 129-159. "Kame Moraine at Rochester, New York": Amer. Geol., vol. xvi, pp. 39-51.

[2] H. L. Fairchild, "Glacial Lakes of Western New York": Bull. Geol. Soc. Amer., vol. vi, pp. 353-74.

[3] "Glacial Genesee Lakes": Bull. Geol. Soc. Amer., vol. vii, pp. 423-52.

Pre-Laurentian Lakes.[1]

Lake Warren.—The area of Western New York is involved in only the later phases of the Laurentian glacial lake-history. The first of these glacial waters that invaded our area were those of Lake Warren. The beaches of this great lake have been traced about the southern shore of Lake Erie and through Western New York to beyond the meridian of Rochester,[2] with an elevation of 883 feet at the northernmost point.

The Warren waters were drained to a lower level by the ice-front receding in the vicinity of Syracuse sufficiently to uncover land that permitted flow to the Mohawk-Hudson, at a level below that of the former outlet across Michigan to Lake Chicago and the Mississippi.

Lake (*unnamed*; *Geneva Beach*).[3]—A well-defined beach, lying at an elevation of about 700 feet, has been traced for 30 miles along the western side of the Seneca lake valley and westward to Shortsville, while evidences of the same static water have been noted farther west. It is supposed that these phenomena belong to a long pause in the irregular fall of the Laurentian glacial waters from the Warren level to the Iroquois level; but the outlet correlating with the level is unknown.

Lake Iroquois.—This latest glacial water in the region has left the strong, mature shoreline about the Ontario basin, correlating with the ancient channel at Rome, N.Y., opening into the Mohawk.[4] The phenomena are strong, and the main facts in the history are clear. The beaches, like those of the preceding waters, show a decided northward uplift, amounting to five feet per mile between Syracuse and Watertown.

MORAINAL LAKES.

Doubtless many lakes had a brief existence, due to morainal dams, but only a few have been identified, these lying in the valley of the Genesee river. A brief description may be found in a former paper.[5] These were drained by the cutting of rock gorges (see last section of this paper). The largest of these morainal lakes was above Portageville. Another was in the new valley of the river above Mount Morris. Others occupied side or tributary valleys to the Genesee.

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[1] For the latest comprehensive statement of the lake-history in the Laurentian basin as a whole, see article by F. B. Taylor, "X. A Short History of the Great Lakes," in 'Studies in Indiana Geography,' edited by C. R. Dryer. Terre Haute, Indiana, 1897.

[2] H. L. Fairchild, "Lake Warren Shorelines in Western New York and the Geneva Beach": Bull. Geol. Soc. Amer., vol. viii, pp. 269–86.

[3] Ibid., pp. 281-4.

[4] G. K. Gilbert, "The History of the Niagara River": 6th Ann. Rep. Com. of State Reserv. at Niagara. Albany, 1890.

[5] H. L. Fairchild, "Glacial Genesee Lakes": Bull. Geol. Soc. Amer., vol. vii, pp. 449–52.

CHANNELS OF GLACIAL DRAINAGE.

A considerable number of the outlet channels of the larger local glacial lakes have been studied and partly described in the papers to which reference has been made. No outlet of the great pre-Laurentian lakes lies within this area, the Iroquois outlet being to the east. The area does contain, however, the channels which drained the Warren waters down to the Iroquois level, a fall of over 400 feet. These lay along the receding ice-front in the Rochester-Syracuse region. Some were rock channels of considerable duration, while others were shifting channels closely following the glacier foot. These have been studied by Mr. Gilbert, but only a brief notice published.[1]

POST-GLACIAL STREAM EROSION.

The great majority of streams on the low northern plain meander in drift channels, rarely touching the rock, and have done little work of corrasion. The heavier streams have in a few cases done considerable rock-cutting. Of similar age and character to Niagara gorge is the ravine of the Genesee at Rochester, but of less dimensions. This cutting, with that of Oak Orchard Creek, Irondequoit Creek, Seneca River, and all other minor ravines and falls on the northward slopes, at an altitude less than 800 to 880 feet, are subsequent to the time of Lake Warren. Those at an altitude of less than about 400 feet are subsequent to Lake Iroquois. The Genesee ravine at Rochester is mostly post-Iroquois. The fine ravines at Mount Morris and Portage began much earlier, during the Lake Warren episode, as outlets of morainal lakes.

DESCRIPTION OF THE MAP (PLATE XXI).

NUMERALS.—The figures give elevations, in feet, above mean ocean-level. At cities and towns, reference is to top of rail at the principal railway station.

DIVIDES, WATER-PARTINGS.—These are indicated by the heavy broken lines. Cols which are known to have been outlets for glacial lakes are indicated by bars placed transverse to the line of water-parting. The figures giving the elevation of such cols are also placed transverse.

MORAINES.—The morainal belts have not been traced east of the Genesee river, and cannot exist there in so good form as in the area west of the Genesee. Throughout the region of the "Finger Lakes" the morainal drift is chiefly massed in the deep north and south valleys, as indicated. North of those lakes the drift was deposited in the presence of deep glacial waters, and morainal lines are scarcely traceable.

The terminal moraine, past the cities of Olean and Salamanca, is not as definite a belt as the map would suggest.

KAME AREAS.—A few well-known areas of heavy water-laid drift are indicated south of the two great bays in the south shore of Lake Ontario, but other areas exist, notably in the Genesee valley, and associated with the larger moraines. South of the great divide the valleys are deeply filled with the detrital overwash from the glacial floods.

DRUMLINS.—The areas of drumlins are only very roughly suggested. The orientation of the drumlin axes is better indicated.

GLACIAL LAKE SHORELINES.—Three shorelines are indicated: the lowest, Iroquois, with an average elevation in the Finger Lake region of 440 feet; the

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[1] G. K. Gilbert, "Old Tracks of Erian Drainage in Western New York": Bull. Geol. Soc. Amer., vol. viii, pp. 285-6.

Geneva beach, 700 feet; and the Warren shoreline, about 880 feet. Another still higher shoreline exists in at least the Seneca and Cayuga valleys, but is indicated on the map, as its east and west limits are not yet determined. This is shore of Lake Newberry, having its outlet south of the present Seneca, by the 900 col—the Horseheads Channel.

The Iroquois shoreline is represented as continuous, although from Sodus eastward it is broken and indeterminate.

The waters producing the Geneva beach certainly occupied a large area, but a little is at present known of that lake, the shoreline is represented only along west side of Seneca valley, where it has been continuously traced.

The Warren shoreline has been continuously traced eastward to beyond meridian of Rochester, and good spits and bars have been found in the Cay valley. The theoretical limits are indicated as far east as the first spillway of lowering waters.

II.—Do the Crystalline Gneisses represent portions of t Original Earth's Crust?

Presidential Address read before the Liverpool Geol. Soc., October 12, 1897.

By Joseph Lomas, A.R.C.S., F.G.S., Pres. Liverpool Geol. Soc.

IN order that progress may be made in any branch of geology is necessary, not only that the faculties of observation a inductive reasoning should be employed, but a proper use sho be made of the imagination. By this means new lines of resea are laid out. The theory we set ourselves to prove may eventua prove to be wrong, but it often happens that the pursuit of a fa theory brings one as near the truth as the following up of a t one. It is in this spirit I wish you to regard the problems a speculations to which I now invite your attention.

The oldest rocks with which we are acquainted are the crystall gneisses and schists which form the lowest divisions of the Archæ Geologists are far from being in accord as to their origin. So regard them as altered sedimentary rocks, metamorphosed to su a degree, that they have been fused to form igneous rocks ane and whilst they were in a fluid or semi-fluid condition, at a gr depth below the earth's surface, they received the characters foliation and schistosity which most of them show. Others rega them as igneous rocks which have been altered by flow and she Others, again, prefer to look upon them as remnants of the crust the earth when it first consolidated from the liquid state.

They are the only rocks which can be regarded as formi a continuous shell round the earth. On them, as a foundati all the later formations have been deposited.

Professor Lapparent[1] refers to the remarkable uniformity of th primitive rocks. In Brittany, the Pyrenees, Alsace, Bavaria, t Alps, Saxony, Scandinavia, Great Britain, Spain, Algeria, No America, Brazil, and China, and wherever they are found, the sa succession can be made out—gneissose or granitoid at the base a schistose above. Chemically they are very much alike, except t alkalies predominate in the gneissose rocks, and calcareous mater in the schistose. He regards them as having been produced on t solidification by cooling of the earth; and as having been formed in a sea of high temperature, charged with chemically active substances and subject to the frequent intervention of adjacent liquid magmas.

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[1] "Traité de Géologie," p. 675.

The continuity of these ancient rocks and their persistent characters certainly point to a cause of origin which was world-wide in its effects rather than local. The main difficulty is to find a worldwide cause which could produce the foliation so characteristic of these rocks in all parts of the globe.

Modern researches show that gneissose and schistose structures can be induced either by fluxion or shearing, or by both combined.

The ancient gneisses are usually found as low hummocky hills; when sufficiently denuded a core of granitoid rock is seen, and the foliations of the flanking parts are parallel to the axes of the ridges. Sir A. Geikie[1] remarks on the similarity of scenery which these rocks show in places where they crop out. A person situated in the central part of Anglesey might very well, so far as the landscape is concerned, imagine himself in the wilds of Sutherlandshire.

Professor G. H. Darwin[2] has demonstrated that in early times the moon was thrown off from the earth, and while it was still in proximity to the parent planet great tidal waves would result from its journey round the earth. The plane of the moon's orbit being but little removed from the earth's equator, the retardation of the diurnal motion of the earth, due to tidal friction, would be greater at the equator than at the poles. "Now, this sort of motion, acting on a mass which is not perfectly homogeneous, would raise wrinkles on the surface. . . . . In the case of the earth the wrinkles would run north and south at the equator, and would bear away to the eastward in northerly and southerly latitudes. . . . . The general configuration of the continents (the large wrinkles) on the earth's surface appears to me remarkable when viewed in connection with these results."[3] These conclusions of Professor Darwin were arrived at altogether independently of geological reasoning, and it may be worth while to consider whether we have any geological evidence to support his theory.

The result of the moon's action on the earth in early times, then, would be a screwing or twisting of the surface layers. This raised them into wrinkles or ridges north and south at the equator, and partaking more and more of an easterly direction as we approach the poles. It is probable that at this time the earth was in a highly heated condition, and thus flow and shear of the surface parts over the lower would combine to produce the wrinkles. Probably the wrinkles were formed very slowly, by the gradual accretion of small stresses acting over long periods, in a manner so well illustrated by our ex-President when speaking of the flow of rocks by alternate expansion and contraction.[4]

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[1] "Ancient Volcanoes."

[2] Phil. Trans. 1879, p. 589.

[3] Ibid. Also read in this connection, chap. ix, "Physics of the Earth's Crust," O. Fisher.

[4] "Origin of Mountain Ranges," by T. Mellard Reade; see also GEOL. MAG. 1894, pp. 203-14.

Sir A. Geikie, in opposing the view that the fundamental gneisses and schists represent portions of the earliest crust that consolidated on the surface of the globe, says:[1] "The coarsely crystalline condition, even of those portions of the gneiss which seem most nearly to represent original structure, the absence of anything like scoriæ or fragmental bands of any kind, and the resemblances which may be traced between parts of the gneiss and intrusive bosses of igneous rock, compel us to seek the nearest analogies to the original gneiss in the deep-seated masses of eruptive material." I may remark that a coarsely crystalline condition is a measure of the rate of cooling of an igneous mass rather than of its depth below the surface.

Professor Bonney says:[2] "The crust itself must have solidified under conditions materially different from those of a lava stream at the present day; for not only is crystallization affected by pressure, but also radiation would then be comparatively slow, because the atmosphere would differ much less in temperature from the solidifying rock than the air now does from the surface of a lava stream. . . . . The weight of the atmosphere would be augmented by that of a shell of water of the area of the globe and two miles in thickness; or, in other words, the atmospheric pressure would be then about 350 times its present amount."

Another objection has been raised by Mr. T. M. Reade:[3] "The evidence that the Archæan rocks the world over have been buried under immense bodies of sediment, of which they may have formed the lower series before the deposition of the Palæozoics upon them, then, seems to be irresistible." In answer to Mr. Reade I may say that it would be most remarkable if every trace of these "immense bodies of sediment" had been removed before the earliest sedimentary rock now found was deposited. Undoubtedly there were sedimentary rocks earlier than the Cambrian, such as the Torridonian and Longmyndian, but wherever they are found they lie unconformably on the gneisses and contain fragments of the fundamental rocks, which show foliation. Foliation, then, could not be the result of overlying sediments, as the structure was developed before the oldest sedimentary rocks with which we are acquainted were laid down. I hope to point out later, that there is evidence to show that some of these gneisses have never been covered at any period of the earth's history.

According to Professor Darwin the primitive wrinkles would trend about N.E.–S.W. in our latitude. The ancient gneisses of Wales, Scotland, and Scandinavia, all have a strike about N.E.–S.W. Comparative geology is as yet in its infancy, and information regarding some of the places where Archæan rocks are exposed is not easily obtained. So far as I have been able to glean information on the point, I have not found an instance which is not in accord with the above theory.[1] Some of the ridges would probably be of continental importance, but with smaller corrugations riding on them.

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[1] "Ancient Volcanoes," p. 116.
[2] "Story of our Planet," p. 341.
[3] "Origin of Mountain Ranges," p. 150.

We will suppose now that the earth's crust has become solid, and the wrinkles remain as long parallel ridges and hollows. It is inconceivable that they should ever unfold again. They might rise or fall as parts of greater movements, or their symmetry and continuity might be destroyed by other foldings not parallel with themselves, but otherwise they could only become degraded by the forces of denudation. We must look upon these primitive ridges, aided to a certain extent by volcanic material which has welled up through the crust in later times, as the source of all the sedimentary rocks. The crests have become denuded, and the products of disintegration have been transported by various agents and laid down on the floors of the troughs. The material of the oldest sedimentaries must have been derived from the highest parts of the ridges, and that forming the newer sedimentaries must have been furnished by the deeper parts of the ridges. This rule, of course, only applies so long as deposition continues (in Wales practically to the end of the Silurian). If the sea-bottom becomes raised to form land, then the sedimentary rocks themselves become denuded, and the tracing of a particle to its ultimate source becomes a complex problem.

If the picture drawn above of the relief of the land in early times be true, the oldest sedimentary rocks should attest the fact by their characters and distribution. Professor G. M. Dawson, speaking of the Archæan sedimentary rocks of Canada, says:[2] "We find long bands of strata, referable to the Huronian and Grenville Series, occupying *synclinal troughs*, more or less parallel to each other and to the foliation of the Fundamental Gneiss, the strata, as well as the foliation, being in most cases at high angles, vertical, or even reversed." Many other instances might be quoted from America, where the sedimentary rocks of Pre-Cambrian age are described as being laid down in long parallel troughs with sides composed of Fundamental Gneiss. In Europe "the oldest beds of Bohemia form a *basin* some 90 m. long and 10–12 m. broad, the principal axis running in a south-west direction from Prague through Beraun to Pilsen. In consequence of this very regular structure, the oldest beds occur at the boundary and the newest in the middle of the basin, whilst the floor of the trough is made up of Archæan rocks, and, above them, of unfossiliferous, phyllitic schists, called the Przibram schists by Lipold, which include locally conglomerate, sandstone, and oolitic limestone."[3]

In Britain the same story is told. The Archæan rocks of Anglesey and the Lleyn Peninsula, and those of the Midlands, form ridges about N.E.–S.W., which bound a trough in which are contained the Cambrian and Silurian deposits. Further west the folds are repeated in the N.W. Highlands, and eastwards, under the capping of newer rocks, into Normandy, Scandinavia, etc.

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[1] Mr. R. Gascoyne, who has just returned from Chili, informs me that the strike of the Archæans in that country is about N. and S.

[2] President's Address, Section C (Geology), British Association, 1897.

[3] Kayser-Lake, "Text Book of Comparative Geology," p. 39.

The characters of the oldest sedimentary rocks lend aid to the theory that they were laid down in long, parallel trough-like depressions. Dr. Hicks, speaking of the Lower Cambrian, says:[1] "The deposits must have accumulated with comparative rapidity in fairly shallow water." Shallow-water deposits imply proximity to land. We cannot obtain shallow-water rocks, extending as they do in separate troughs from Britain to Russia, on the assumption that they were laid down in a continuous sea extending across Europe. Dr. Hicks many years ago propounded this theory to account for the distribution of the Cambrian rocks.[2]

It is probable that the primitive ridges were not very lofty. They would, no doubt, form the counterparts of the troughs. Professor Lapworth has shown[3] how persistently a lofty fold is counterbalanced by a deep parallel depression, and a low ridge by a shallow trough. Dr. Hicks suggests[4] that high mountains existed in Pre-Cambrian times, and that some of them were probably snow-covered. So far as I can gather, the only reason why he postulates these high mountains is to explain the occurrence in the Cambrian conglomerates of boulders over a foot in diameter. In mountain-building, as in everything else about us, there has been a gradual evolution going on. The Tertiary is the epoch of mountain-building, and there has probably been a progression in the heights of mountains from ancient to modern times.

The tracing out of old shorelines, and the mapping of former distribution of land and water, form a branch of geology which has of late come into prominence.

Pioneer work has been done by Godwin-Austen, Professor Hull,[5] Jukes-Browne,[6] and others, but much will need to be done before we can draw maps which will show the distribution of land and water in Palæozoic times with accuracy. The maps published by Professor Hull and Jukes-Browne must not be taken as being absolutely correct, especially in the Palæozoic period. We may, however, regard them as approximations to the truth. I had occasion recently to copy out on tracing-paper the Palæozoic shorelines as given by Jukes-Browne. On accurately registering these and holding them up to the light, I was struck with the fact that in some districts there was a great closing up of shorelines. This was especially noticeable about Anglesey, where within a few miles of each other the Cambrian, Ordovician, Silurian, Carboniferous, and Permian shorelines are found. It would seem as though in Anglesey we were dealing with a very stable part of the earth's crust, a part which had kept its position relatively to the sea nearly the same through long ages. As there is every reason to believe that Anglesey kept its head above water during the Mesozoic and Cainozoic Periods, it follows that portions of the Archæan rocks on the north-west of the island have never been submerged at all.

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[1] President's Address, Geological Society, 1897.

[2] Q.J.G.S. 1875, p. 552.

[3] President's Address, Section C, British Association, 1892.

[4] GEOLOGICAL MAGAZINE, 1876, p. 157.

[5] "Contributions to the Physical History of the British Isles."

[6] "The Building of the British Isles."

A second aggregation of shorelines is seen in the Midlands, closely following the Archæan ridge. This is not so striking an example as that in Anglesey, but it is sufficient to suggest that the solid cores of the primitive wrinkles have resisted great lateral crushings, while the sedimentary rocks deposited in the troughs have been crushed, folded, and cleaved to a great degree. We might almost compare the ridges to nodes in the great wave-like motions which have swayed the surface rocks up and down like long ocean swells.

In order to bring the arguments given above into better view, I may summarize the chief points touched upon.

1. The worldwide distribution of the fundamental gneisses and schists and their uniformity of characters suggest a cause which affected the world as a whole.
2. Professor Darwin has shown, altogether apart from geological reasoning, that primitive wrinkles would be formed on the crust by the action of the moon when nearer the earth. So far as I have been able to gather, the ridges formed by the oldest rocks now existing correspond in direction with the wrinkles Professor Darwin describes.
3. The lithological characters of the primitive rocks are such as would result from the flowing and shearing of rocks (in which crystals had already formed but were in a highly heated condition), on being raised into wrinkles by differential movements.
4. The earliest sedimentary rocks were deposited in long troughs, parallel to each other for the same latitude.
5. The ridges themselves never unfolded. Some of them have remained at approximately the same level through all time, and others have partaken of greater movements in later times. The continuity of the ridges has been destroyed in some places by later foldings not parallel to themselves.

And now, in conclusion, may I refer to a matter which arises directly out of the subject-matter of the Address? In many text-books, and even in geological papers, the young student is told in effect that "every part of the earth has been raised and depressed times without number." As our knowledge increases I believe that this loose and offhand method of dealing with earth-movements will give place to more precise and definite statements. It will then be found that changes of level have not taken place promiscuously, but according to certain laws, of which we have at present only the foreshadowing. I do not refer so much in this matter to local movements, which can be traced to obvious local causes, but rather to those extending over great areas. A large movement must have a deep-seated cause, which will leave permanent witness to its operation.

All branches of science must necessarily pass through three stages—(1) the observation of facts; (2) the enunciation of theories to explain the facts; (3) the discovery of laws governing all. In geology many facts have been gleaned, many theories have been launched, and of these precious argosies, only the seaworthy, those built in conformity with natural laws, will arrive in port.

III.—On *Ceratodus Kannemeyeri* (Seeley).

By H. G. Seeley, F.R.S., Professor of Geology in King's College, London.

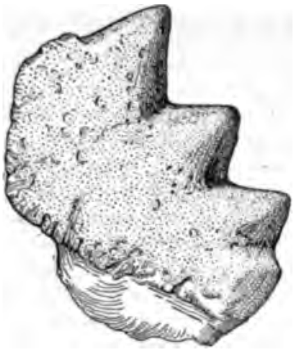
Dr. DANIEL RUSSOUW KANNEMEYER sent me a photograph of a dental plate in April, 1897, to which was appended the remark—"I conclude it to be *Ceratodus*, and its bones are said to be lying at Kraai Fontein. I have sent the man who found it to search for and fix the locality." The search was not successful; and since then the rinderpest has prevented any attempt to reach the locality, which is geologically at the top of the Karoo beds above the Coal of the Indwe district of Cape Colony, in strata which yield Zanclodont reptiles in other localities. It may therefore be classed as of Triassic age, belonging to the Stormberg Series, and well above the Permian rocks which have yielded Theriodonts. This determination is of some interest as contributing to define, by means of a well-marked Trias genus, the age of the upper limit in South Africa of strata which have yielded Theriodont and Dicynodont reptiles. Such a division between Trias and Permian agrees with the grouping of the rocks to which I was led by a physical examination of the country in 1889.

Failing for the time to obtain the other reputed remains, Dr. Kannemeyer has recently sent me the tooth, which differs as a species from all known types. In 1889 Mr. A. S. Woodward (Ann. and Mag. Nat. Hist., Sept., p. 243) mentioned and figured a small example of a tooth of *Ceratodus*, found at Smithfield in the Orange Free State, which he named *Ceratodus Capensis*. It is distinguished from the new form, which I associate with the name of Dr. Kannemeyer, by the narrow rounded ridges which diverge over the dental plate, as well as by the relatively broader form of the plate, and by its thinness; and *C. Capensis* differs from the common forms of the Muschelkalk and Rhætic beds of Europe by such characters as separate it from the new African species (see Figure).

The left superior dental plate of *Ceratodus Kannemeyeri* is thick and flat, with a nearly vertical serrated external border made up of three strong wedge-shaped denticles, with a slight convexity in front and a marked convexity behind them. The plate has a thick base, which is prolonged backward in a way seen in some species from the Trias of Germany, but the base does not extend to the inner anterior border of the dental plate, which may possibly be a line of union with the corresponding plate on the opposite side of the palate.

The specimen measures 4·5 cm. from front to back. The extreme transverse width over the first denticle is 3·5 cm., while over the

third or hindermost denticle the width is 2·1 cm., exclusive of the base; but including the base, the transverse hinder measurement is 3·1 cm. The three wedges which form the external margin diminish in size successively from front to back. The notch between the first two is almost exactly a right angle, and the notch between the second and third is rather less than a right angle. The thickness of the dental plate, including the base, is 1·8 cm., but above the base it is about 1·3 cm. thick. The sides of the notches which define the denticles are flat, smooth, and so formed that the notch extends a little inward as it meets the nearly horizontal crushing surface; and the flat sides converge outward to form the sharp external angles of the wedges, which round convexly along the crest of each on to the flat surface of the plate.



Left Dental Plate of *Ceratodus Kannemeyeri.* Natural size.

The tubuli of the dental plate are vertical in all parts of the tooth, and are arranged in linear series, so that they form labyrinthic patterns, which have a general extension in the longitudinal axis of the tooth and extend transversely across the three external denticles, but are parallel to the external margin of the posterior rounded convexity, which is rather more elevated than other parts of the tooth. It is probable that this pattern is exposed by removal of the enamel.

The fossil resembles *C. Guilielmi* (Plien), from the Muschelkalk of Hoheneck, in form of the dental plate and its flatness, and in character of the denticles; but differs in having only three denticulations, with terminal convexities back and front. It also may be compared with *C. Hislopianus* from the Gondwana beds of Nagpur, in the thickness of the dental plate, which involves some resemblance in the denticles; but in that Indian species there are five denticles instead of three, and the plate is relatively narrower. There is no species with a similar broad flat crushing surface, and three thick wedge-shaped denticles, which decrease in size from front to back.

IV.—On a Method of Determining the Actual Direction of Movement, whether Lateral or Vertical, in Faults.

By Philip Lake, M.A., F.G.S.

In calculating the throw of a fault, it is usual to assume that the whole of the displacement due to the fault has been produced by a vertical motion—i.e. by a motion in a vertical plane at right angles to the direction or strike of the fault—and that there has been no such thing as a lateral movement of one face of the fault upon the other.

Suppose, for example, that in Fig. 1 the plane of the paper is the plane of the fault, that the heavy line A B represents the outcrop or "trace" of a bed upon one of the faces of the fault, and the light line A′ B′ the outcrop or "trace" of the same bed upon the other face, the horizontal line being the surface of the ground. It is almost universally supposed (in practice at least) that before the formation of the fault the point A was in coincidence with the point A′ (which is now vertically below it), and the point B with the point B′; and that the line A A′ or B B′ shows both the direction and amount of the movement.

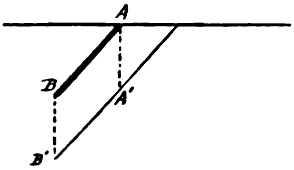


Fig. 1.

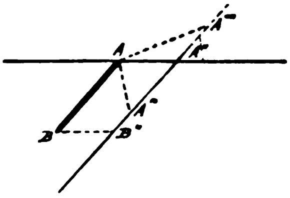


Fig. 2.

But this may not be true. It is possible that A may have coincided with A″ (Fig. 2) and B with B″; the movement may have taken place along the lines A A″, B B″, or, in other words, may have been entirely lateral or horizontal. Or the point A may have coincided with some other point A‴ or A⁗; and in that case the movement must have taken place along the line A A‴ or A A⁗, and must have been partly horizontal and partly vertical. Yet the result is apparently the same; and it is impossible, therefore, in such a case, to determine the actual direction of the movement. When, however, the fault crosses an anticlinal or a synclinal, the effects of lateral, as opposed to vertical, motion are sometimes so clear that they have already attracted attention.

Most of the textbooks explain the effect of a fault upon an anticlinal on the assumption that the movement has been purely vertical. They show, if the ground be level, that the two outcrops of a bed on the downthrow side of the fault will lie closer together than the two outcrops on the upthrow side; and they show, moreover, that if the outcrops on the downthrow side be produced across the fault they will lie between the outcrops on the upthrow side (Fig. 3). A little consideration will make it clear that the position of the anticlinal axis upon the map is entirely unaffected by such a fault, because it has simply been shifted vertically. If, however, the movement of the one face of the fault upon the other has been horizontal instead of vertical, the whole anticlinal will have been thrown to one side; and the outcrops on one side of the fault will no longer, if produced, lie between the outcrops on the other side (Fig. 4).[1]

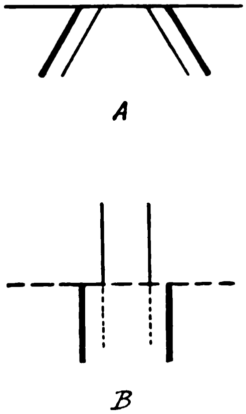


Fig. 3

Anticlinal faulted by a fault, the movement along which has been vertical.

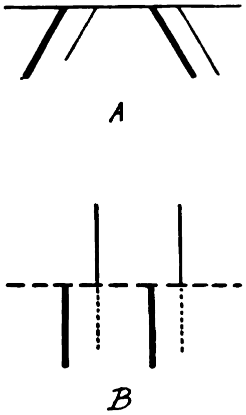


Fig. 4

Anticlinal faulted by a fault, the movement along which has been horizontal.

A shows the two faces of the fault, as in Figs. 1 and 2. *B* Plan.

Cases of this kind are by no means rare, and must have led many geologists to reflect that no amount of vertical movement can account for them. Between Aber and Bethesda, for example, there is an anticlinal of Lingula Grits crossed by a series of parallel faults. Most of the faults produce no effect upon the axis of the anticlinal, but the one on Ffridd-du shifts the whole anticlinal several hundreds of yards to one side.[2] More striking still is the fact that during one or two recent earthquakes visible faults have been formed accompanied by a lateral displacement of the ground on one side of the fault.[3]

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[1] The converse case of a synclinal is so similar that it is unnecessary to refer to it here.

[2] See Quarter-sheet 78 S.E. of the Geological Survey of England and Wales. A map of the area is also given in "The Geology of North Wales" (Mem. Geol. Surv., vol. iii), 2nd ed., p. 202.

[3] See, for example, "Notes on the Earthquake in Bâluchistân on the 20th December, 1892," by C. L. Griesbach: Rec. Geol. Surv. India, vol. xxvi (1893), pp. 57–61, 3 plates. The chief evidence of lateral displacement is the disturbance of

It is certain, therefore, that in some cases an actual, and not merely an apparent, lateral displacement has occurred during the formation of a fault. But so far as I am aware, no one has yet shown how to determine the real direction of the movement and the inclination of this direction to the horizontal. If all the beds affected by a fault dip at the same angle and in the same direction, the problem is indeed insoluble. But if the dip be not uniform, if the beds be in any way bent or folded, the solution is theoretically easy.

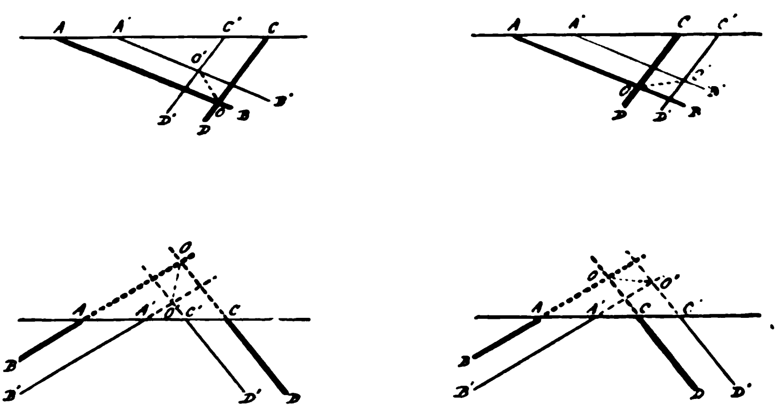

Fig. 5.

Method of finding true direction of movement.
(The description applies to any of these four diagrams.)

Suppose that in any of the four diagrams in Fig. 5 the plane of the paper is the plane of the fault; that the heavy lines A B, C D represent the outcrops of beds (having different dips) upon one face of the fault; and A′ B′, C′ D′ the outcrops of the same beds upon the other face. Produce A B and C D to meet in O, A′ B′ and C′ D′ to meet in O′. Then the line O O′ lies in the direction in which one face of the fault has moved upon the other, and the length O O′ is the amount of the movement. For the effect of the fault is as if the line A B were moved bodily into the position of the line A′ B′,[1] and the line C D into the position of the line C′ D′. Now the point O is a point in the line A B, and it must therefore

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a railway line. This alone, however, would not be conclusive, for railways are but loosely attached to the earth. A similar disturbance of a railway line was produced in the recent Indian earthquake of the 12th June, 1897; but the figure given by Oldham (Rec. Geol. Surv. India, vol. xxx, pl. xvii) seems to show that the sides of the railway track, as indicated by the lines of vegetation, remained undisturbed.

[1] This does not mean that the *point* A is moved to the position A′, or B to B′; but that the line A B (which may be imagined to be indefinitely produced) is moved to the position of the line A′ B′ (also indefinitely produced).

have moved to some position in A′ B′. It is also a point in the line C D, and therefore it must have moved to some position in C′ D′. Consequently the new position of the point must lie both in A′ B′ and in C′ D′, and it must therefore lie at their intersection O′: the effect of the fault has been to move the point O to the position O′, and every point in A B and in C D has moved along a line parallel and equal to O O′.

It may be remarked here that it is impossible to say whether A B or A′ B′ was the original position of the bed, and it is therefore impossible to determine whether the movement took place from O to O′ or from O′ to O.

If the movement has been uniform throughout the area considered, then the solution is perfectly general. A B and C D may or may not be the same bed. The line A C need not be horizontal or even straight. The positions of A and C with respect to each other may be chosen quite arbitrarily. The only conditions to be satisfied are that A A′, A B, A′ B′, C C′, C D. and C′ D′ make the proper angles with the horizontal; and that A A′ and C C′ be drawn according to the particular scale selected. If this be done, then O O′ will also make the proper angle with the horizontal and will be on the same scale as A A′ and C C′. It must be noted, however, that the angles which A B, C D, etc., make with the horizontal, are not the angles of the *true* dips of the beds in question, but the angles of the apparent dips *in the plane of the fault.*

Although the solution is general, there are many faults to which it cannot be applied, even theoretically. If the lines A′ B′ and C′ D′ are not parallel respectively to A B and C D, the problem is insoluble, because the movement has not been uniform. All that we can do is to determine the direction of motion at some particular spot.

As the displacement due to a fault is probably never the same throughout its whole length, it is advisable to take beds A B and C D, which are in actual fact near to each other; and as a general rule there are no cases more favourable for the application of the method than unconformities, where beds of different dips are found one above another.

V.—The Age of the Rand Beds.

By W. Gibson, F.G.S.

In several parts of South Africa, thick sedimentary and unfossiliferous deposits are found resting on gneisses or highly altered rocks. They are well developed in the Southern Transvaal around the towns of Johannesburg and Potchefstroom; in the Northern Transvaal in the districts of Lydenburg and De Kaap, and possibly Zoutspansberg; in Matebeleland, Bechuanaland, Griqualand West, Damaraland, and Zululand. These widely distributed sediments have been generally taken as representing the whole or portions of the sedimentary series typically developed in the Southern Transvaal.

The sequence in the Southern Transvaal is as follows, in descending order:—

1. Gat's Rand Beds, Megaliesberg Beds.
2. Rand Beds.
3. Quartzite and shale group (Hospital Hill Series).

The Gat's Rand series are now considered to be unconformable to the Rand Beds. A dolomite from which Mr. Draper[1] has obtained fossils of doubtful Carboniferous species is associated with the Gat's Rand Beds. It is only the age of the Rand Beds that is here considered.

As investigation is carried on among these rocks, they are found in several areas to be more strongly affected by mechanical movements than any of the rocks newer than the Table Mountain Sandstone of Cape Colony.[2] In the Cape, the folding of the Table Mountain Sandstone and overlying Palæozoic rocks is of Post-Karoo age, the Karoo beds being involved in the folds.[3] Where the Karoo beds exist in the vicinity of the highly inclined and altered Rand Beds, they are nearly horizontal or but slightly inclined. It would therefore seem that the deformation of the Rand Beds is older than the folding of the Palæozoic rocks of Cape Colony.

Another fact in favour of the great age of the Rand Beds is the intrusion into them of basic dykes, which have been converted by pressure into hornblendic and chloritic schists. In the Cape Colony, igneous intrusions, so far as I am aware, are absent from the formations between the base of the Table Mountain and the top of the Zwartebergen Group, while the dykes and sills piercing the Karoo beds are unaltered. Igneous intrusions, in beds older than the Karoo, are confined in Cape Colony to the Malmesbury Schists.

The rocks in Cape Colony that appear to have the closest lithological resemblance to those of the Rand are some slates, grits, and sheared conglomerates found in the Prince Albert Region. These are doubtfully considered by Dr. Corstorphine to overlie the Zwartebergen Quartzites,[4] but as a dolomite is associated with these grits and conglomerates, they would appear to represent the Megaliesberg Group.

Up to the present date the Rand deposits are generally considered to be represented by some portion of the Table Mountain Sandstone series. If so, in the Transvaal there are evidences of a complex series of folds and overthrusts of Pre-Karoo age unrepresented in Cape Colony, except perhaps in the Malmesbury Schists. On the other hand, in Cape Colony and Natal there are evidences of a folding of Post-Karoo age which is not represented in the Transvaal. If a comparison between regions so widely separated as the Southern Transvaal and the Cape be of any value, there seems more probability of the Rand Beds belonging to the Malmesbury Group than to any newer formation.

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[1] D. Draper, "The Occurrence of Dolomite in South Africa": Quart. Journ. Geol. Soc., vol. xv, p. 561, 1894.

[2] W. Gibson, "The Geology of the Gold-bearing and Associated Rocks of the Southern Transvaal": Quart. Journ. Geol. Soc., vol. xlviii, pp. 404-37, 1891. W. Gibson, "Geology of the Southern Transvaal": Trans. Fed. Inst., vol. vi, p. 124, 1893. A. R. Sawyer, "Remarks on the Banket Formation at Johannesburg, Transvaal": Trans. Fed. Inst., vol. ix, p. 360.

[3] E. H. L. Schwarz, "First Annual Report of the Geological Commission of the Cape of Good Hope for 1896," p. 28.

[4] Dr. G. S. Corstorphine, "First Annual Report of the Geological Commission of the Cape of Good Hope for 1896," p. 31.

NOTICES OF MEMOIRS.

I.—THE SO-CALLED LODE FORMATIONS OF HANNANS, AND TELLURIDE DEPOSITS, IN WESTERN AUSTRALIA.[1] By H. P. WOODWARD, Assoc. M. Inst. C.E., Memb. Inst. M. & M., F.G.S., etc.

HANNANS, as it was originally called, was named after the discoverer, Patrick Hannan, but its name has been recently changed by the Government officials to Kalgoorlie, the native name of a small hill that is situated close to the township. It is about 400 miles from Perth by railway, in the East Coolgardie Goldfield; this field is the smallest, but at the same time it produces the largest quantity of gold of any in the colony. A solid block of country has been taken up upon gold-mining leases, of about 10 miles in length and 2 miles in width, comprising over 700 leases, of which some ten produce almost the entire output of gold of the district.

The great discovery of the district was made at a point about 4 miles south of the township, where a group of mines is being worked which bids fair to equal the richest known mines in the world.

Geology.—The flat surface of the country is covered by a deposit of red loam, beneath which in some places a considerable thickness of blue clay is met with, whilst near the hills it is of only slight thickness. This clay rests directly upon the auriferous series, fragments of which, associated with ironstone and a little quartz, are strewn over the surface, and constitute the dry-blowing patches.

The low range of hills which extends from Kalgoorlie to the Boulder, consists of hard, fine-grained hornblendic schists, intersected by numerous diorite dykes, the whole being capped in many places by deposits of ferruginous claystone.

The rocks, like most of those occurring in Western Australia, do not appear to be of sedimentary origin, but most probably owe their stratified appearance to crystallization under pressure; and they have since been crumpled into a number of anticlinal and synclinal folds, the strike of the axial planes of which is a few degrees west of north.

Lodes.—The lodes or formations, as they are called, are decidedly peculiar, consisting, as they do near the surface, of an indurated mottled ferruginous claystone, which has proved in places to be extremely rich in gold; but, strange to state, where such was the case, little or no gold upon the surface was discovered, clearly proving that no denudation has taken place since the gold-bearing portions of the lodes were uncovered. One of the characteristic features of the Western Australian goldfields is the almost total absence of alluvial deposits containing gold. Those surface patches which have been worked owed their origin entirely to atmospheric agencies, which have also often altered the rocks and lodes to a considerable depth from the surface. Another peculiarity of the Hannan's field is the scarcity of quartz and absence of well-defined quartz veins, thus proving conclusively that the surface gold, which shows no sign of water action, is derived from the weathering *in situ* of belts of country rock traversed by small but rich veins.

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[1] From the Transactions of the Institution of Mining and Metallurgy, October 20, 1897.

The lodes, when opened up in the decomposed zone, do not exhibit the general characteristics of true fissure veins, since they rarely have defined walls or slicken-sides to prove that any sliding action has taken place, and when they have, such walls are of limited extent. Moreover, it does not follow that all the material which appears to be lode matter between such walls, or between the points at which the solid blue country is met with, is all ore.

The whole lode formation has a banded or schistose appearance and is mostly of a brownish colour, due to the presence of hydrated oxides of iron; and it is soft and greasy to the touch, owing to the fact that it consists largely of hydrated silicates of alumina and magnesia.

Small decomposed quartz veins, which are often ferruginous, intersect the lode mass, and it is where these are met with that the lode is found to be richest, all the coarsest gold being associated with the quartz. When these veins are entirely absent, little or no gold is met with; and when it does occur, it is in a very finely divided state disseminated throughout the entire mass.

At the surface, the lodes apparently run in a more or less north and south course; and since there is not a continuous outcrop, an individual lode cannot be traced with the slightest degree of certainty for any great distance. This is further rendered difficult by the fact that several of these lodes are often met with close together, and following apparently the same course, or nearly so, as the lode which it is desired to follow.

There appear to be few continuous lodes, most of them proving to be lenticular. These lenticular masses are found to lie one on another in splice fashion; therefore, when one pinches, if a cross cut is driven east and west, one or more lodes are almost certain to be cut at no great distance from that which has pinched; but although such lode or lodes may, to all appearances, contain similar material, it does not follow that it will be as rich in gold. The rich ore appears to run in well-defined shoots, which dip to the south, varying in width from a few inches to several feet, and in length up to several hundred feet; the entire mass of which mostly goes from 3 to 4 ounces, whilst large portions are often as rich as from 10 to 20 ounces.

This decomposed zone in the lode varies in places from 60 feet to 300 feet from the surface; the greatest depths to which it has extended in many cases correspond with the richest portions of the lodes.

In the mineralized portions of the lode, a great change in its character is to be noticed, and it has, if anything, still less the appearance of a true lode than that nearer the surface; however, it continues to be equally as rich, but the gold, instead of being free, occurs in the form of a telluride. The ore is a bluish-green siliceous rock, often thickly studded with minute crystals of pyrites, and intersected by quartz veins, which are the richest portions of the lode; but here, as in the decomposed zone, the gold is found to extend often for a considerable distance into the mineralized rock upon either side of these veins.

Portions of this rock, taken from near the quartz veins, often contain large quantities of small crystals of telluride of gold, pyrites, calcite (which also occurs in veins and vughs), and probably serpentine, thus presenting an entirely different composition from the hornblende and felspar rocks which constitute the country rock, but into which it merges so gradually that it is impossible to say where one ends and the other begins.

The tellurides are met with as veins, splashes, and minute crystals disseminated throughout the entire mass. In the first of these forms, they appear to have been deposited subsequently to the quartz, for the veins intersect the latter, often filling right-angle cracks in them, which, when encountered, make a great show, since they may be seen in places all the way down the side of a shaft for 40 or 50 feet as veins several inches in width, but which upon being broken into only prove to be of slight thickness, with quartz behind them. Fortunately this is not invariably the case, for in many instances small solid veins of the tellurides, quite independent of the quartz, have been traced for a distance of 60 or 70 feet.

Origin of Lodes.—With regard to the origin of the lodes, the only explanation that is tenable is that advanced by Dr. Penrose in his Report upon the origin of the Cripple Creek lodes. This is, that a series of fissures has been formed without any yawning, gaping, or faulting, up which highly heated mineral solutions were forced which permeated the country rock on either side of these cracks, dissolving out certain of its constituents, and replacing them by others, thus altering the nature of the rock to a large extent near the fissure, and gradually less further and further from it until no alteration at all has taken place, and the country rock has remained in its original form.

When a number of these veins are met with, following the same general course, and at no great distance from each other, mineralization has taken place over a greater extent, thus presenting the appearance of a large lode, whilst when only one occurs, the zone of alteration is of course limited, and therefore the lode is said to be small or to pinch. It is almost needless to mention that the richest portions are almost invariably met with at the most highly mineralized points, and hence where the lodes are largest.

The depth to which the zones of decomposition occur vary very greatly, even in a short distance, and bear no relation to the surface contour or to the water-level of the country. At the same time, when the matter is carefully examined, the reason is apparently clear.

The rocks of the district, except in the immediate vicinity of the lodes, have undergone very little change, since they often outcrop, forming bold rough hills, which are strewn with solid masses of rock. When such is the case, and a lode-cap is cut, upon sinking to, say, 50 feet from the surface in the solid ground, it is found to have undergone little or no alteration, which is clearly due to the protection it has received by the 50 feet of solid rock above it that may be said to have hermetically sealed it.

On the other hand, when large rich lodes outcrop, the oxidizing action has followed gradually down the same channels, up which the mineral matter found its way, and has altered it to a considerable depth; whilst in those portions which were poor, and not so highly mineralized, little or no change has taken place, even in the same lode and at the same levels.

The gold in the oxidized zone is clearly derived from the decomposition of the tellurides, since the gradual change from one into the other has been traced, whilst, further, the pyrites proves to contain little or no gold.

II.—Differentiation in Igneous Magmas as a Result of Progressive Crystallization.[1] By J. J. H. Teall, M.A., F.R.S.

CRYSTAL building in an originally homogeneous igneous magma necessarily produces differentiation into portions of different chemical composition, a fact the importance of which was first impressed upon the author sixteen years ago in studying the andesitic lavas and their associated quartz-porphyry dykes in the Cheviot district.

As is well known, Professor Rosenbusch has classified the common constituents of igneous rocks into (1) the ores and accessory constituents (including magnetite, etc.), (2) the ferro-magnesian constituents, (3) the felspathic constituents, (4) free silica; and has maintained that members of group (1) are the first to form in the process of crystallization, and that while there are irregularities of order between members of group (2) as compared with those of group (3), yet the members of these groups separate out *inter se* in the order of increasing acidity. This order of crystallization has been emphasized by many writers, though it has also been clearly recognized that the law is not constant in different magmas and under different conditions. The object of the present communication is to call attention to what is at least an important exception to this law.

Among an extensive series of rocks and fossils collected by the

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[1] Abstract of a paper read at the British Association, Section C (Geology), Toronto Meeting, 1897.

Jackson-Harmsworth expedition in Franz Josef Land, recently examined by the author and Mr. E. T. Newton, are many basalts essentially composed of labradorite, augite, and interstitial matter, in which labradorite formed first, then augite, and last of all the interstitial matter, either with or without further differentiation. The main interest of these rocks lies in the composition and relations of the interstitial matter. This is occasionally present as a deep brown glass, but more often is represented either by palagonite or by a turbid and more or less doubly refracting substance crowded with skeleton-crystals of magnetite. In many specimens it is only in this form that the magnetite occurs, the labradorite and augite being free from inclusions of this mineral. These facts prove that magnetite may belong to a very late stage of consolidation, and that progressive crystallization may lead to a concentration of iron-oxides in the mother liquor.

The palagonite appears to have been formed by the hydration of a deep-brown glass. An analysis was made of it with the following results:—

	I.	II.
Silica	35·48	42·88
Titanic acid	nil	—
Alumina	8·30	10·03
Ferric oxide	12·30	14·87
Ferrous oxide	14·60	17·65
Lime	1·04	1·26
Magnesia	7·10	8·58
Soda	3·92	4·73
Potash	trace	—
Loss on ignition	16·80	—
	99·54	100·00

In the second column the water is neglected, and the percentage composition of the remaining substances indicated. The analysis confirms the view that a great concentration of iron-oxide has taken place, and suggests the further conclusion that there has been a concentration of magnesia and a reduction of the lime, silica, and alumina, thus agreeing with the results of the microscopic examination.

Several observers are quoted by the author as having established the fact that magnetite is not always one of the earliest minerals to form, and in basalts of the Franz Josef Land type there is clear evidence that a basic magma may consolidate without any separation of this mineral, although the mother liquor may contain 30 per cent. of iron-oxides.

Brögger, Vogt, and others have observed a tendency in certain dykes for the molecular groups of which the first-formed minerals are built to migrate towards the cooling margins. The cases examined are mostly those of intermediate rocks, in which the basic minerals are the first to form, so that the margins are more basic than the central parts. But it appears probable that cases occur in which the opposite is true. If the magma of the Franz

Josef Land basalts had cooled slowly in a fissure, we should expect to find the central portion of the dyke richer in iron-oxide than the margin. Professor Lawson has described two basic dykes from the Rainy Lake region, where this is actually the case, and a more striking illustration is seen in the Taberg iron-ore mass, described by Sjögren and Törnebohm, where the marginal portion of an eruptive mass about one square kilometre in area is formed of olivine-hyperite containing only small quantities of magnetite and olivine, and this passes inward by gradual stages into a magnetite-olivinite without plagioclase.

In conclusion, it is asked whether the metallic iron, which occurs as interstitial matter in some of the Greenland basalts, may not have been formed by the reduction, by included organic matter, of the iron-oxides previously concentrated by progressive crystallization.

III.—DRIFT PHENOMENA OF PUGET SOUND AND THEIR INTERPRETATION.[1]

By BAYLEY WILLIS.

THE area from which the facts for this discussion were collected is the Tacoma quadrangle of the United States topographical survey, comprising the district east and south of Seattle and Tacoma. The major topographic features are the channels of the Sound and the strictly homologous valleys now filled with alluvium. These divide, and in some instances surround, plateau-like elevations composed of stratified and unstratified drift that rise about 500 feet above the sea. On the slopes of the adjacent foot hills of the Cascade Range, drift deposits occur up to and beyond 1,700 feet above the sea. Various features of the Glacial-derived topography have been traced out in detail, including characteristic till surfaces, morainic zones, kames, and overwash plains. The distribution of these features indicates that at least the latest Glacial advance was along the valleys and channels of the Sound, and that glaciers rose above and overflowed the margins of the plateaus. The materials of the drift are to a large extent granite, and bear evidence of prolonged water transportation. A distinct variety of till, containing numerous erratics of Tertiary volcanic origin, was found in localities to which it was probably brought from the local centre of glaciation, Mount Rainier. The relation of these local Glacial deposits to the general drift indicates that the prevailing drift phenomena were due to glaciers which penetrated from the north as far south as the foot hills of Mount Rainier, thirty miles south-east of Tacoma.

The detailed examination of the various features of the drift suggests the hypothesis that the channels of the Sound are the hollows remaining after repeated Glacial occupation of a wide valley formerly diversified by the valleys and ridges of Pre-Glacial topography. In the course of repeated Glacial advance and retreat the earlier divides were built upon and transformed into plateau-like eminences of Glacial drift, whereas the occupation of the valleys by Glacial ice, particularly in the stagnant stages of retreat, prevented their being permanently filled; with the final retreat of the ice the molds of glaciers remained as the channels of the Sound. This hypothesis is to be contrasted with that of erosion, due to repeated uplift and subsidence.

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[1] Abstract of paper read before the British Association, Section C (Geology), Toronto, 1897.

IV.—LIFE-ZONES IN THE BRITISH CARBONIFEROUS ROCKS.—Report of the Committee, consisting of Mr. J. E. MARR (Chairman), Mr. E. J. GARWOOD (Secretary), Mr. F. A. BATHER, Mr. G. C. CRICK, Mr. A. H. FOORD, Mr. H. FOX, Dr. WHEELTON HIND, Dr. G. J. HINDE, Mr. P. F. KENDALL, Mr. R. KIDSTON, Mr. J. W. KIRKBY, Mr. G. W. LAMPLUGH, Professor G. A. LEBOUR, Mr. G. H. MORTON, Professor H. A. NICHOLSON, Mr. B. N. PEACH, Mr. A. STRAHAN, Dr. TRAQUAIR, and Dr. H. WOODWARD, appointed to study the Life-Zones in the British Carboniferous Rocks. (Drawn up by Mr. GARWOOD.)[1]

IN consequence of the early date on which it is necessary to submit reports, little work has been done this year up to the present time, but it is hoped that during the summer months progress may be made with the work of the Committee, and collections may be obtained from localities of special importance.

At present a collector is engaged upon the fauna of the Millstone Grit at Eccup, five miles north of Leeds, where a fossiliferous black shale has been met with during the excavation of a puddle-trench for a reservoir. The bed occurs about the centre of the "Middle Grits" of the Yorkshire Millstone Grits.

The bed, which was discovered by Mr. Percy Kendall, some three years ago, contains a rich marine fauna, which has not yet, however, been properly worked out. The fauna includes species of *Nucula* and *Leda* in great abundance and in excellent preservation, also numerous individual specimens of *Lingula* and *Discina*. Gasteropods occur, and a few specimens of *Goniatites*, together with well-preserved specimens of *Conularia*. Several specimens of *Dithyrocaris* have been found, and a single specimen of a minute Trilobite, cf. *Brachymetopus Ouralicus*. Fish-remains referable to two genera have been identified.

The fauna appears to bear little resemblance to that of the Cayton Gill beds of Nidderdale, which lie at approximately the same horizon in the Millstone Grit. On the whole, the fauna appears to resemble in many points that of the Ridsdale Ironstone shale of the Bernician beds of South Northumberland. The Committee hope that the information obtained from this deposit will be of value, in consideration of the comparative neglect with which the fauna of the Millstone Grit has hitherto been treated.

Owing to the temporary nature of the exposure, the Committee considered it advisable to expend a considerable portion of the grant in obtaining the services of a competent collector, who has spent a fortnight in making as exhaustive a collection as possible from the locality, under the superintendence of Mr. Percy Kendall. The accounts have not yet, however, come in, and the Committee cannot therefore at present draw upon the grant generously placed at their disposal by the Association, but ask that the sum granted may be carried over to next year. They also ask that a similar sum may be granted for that year.

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[1] Read before the British Association, Section C (Geology), Toronto, 1897.

The Secretary has been in correspondence with the various members of the Committee as to the best methods of forwarding the objects of the Committee. From many of these he has received valuable suggestions; and it is hoped that reports will be furnished at an early date from each of the members for special districts, giving detailed sections of the rocks in their individual areas, and stating what reliable information has already been collected regarding their fossil contents, and what yet remains to be done in this connection.

REVIEWS.

I.—A Memoir of William Pengelly, of Torquay, F.R.S., Geologist; with a Selection from his Correspondence. Edited by his Daughter, Hester Pengelly, with a Summary of his Scientific Work, by the Rev. Professor Bonney, F.R.S., F.G.S., Honorary Canon of Manchester. 8vo; pp. xii and 342, with a Portrait and 10 plates. (London: John Murray, Albemarle Street, 1897. Price 18s.)

IF it be true that "there's a divinity that shapes our ends, rough-hew them how we will," it is also a trite observation that the physiography and geology of a man's birthplace and early home often exercise a most powerful influence upon his character and career in after life.

Take the case of Hugh Miller, born at Cromarty, with the sound of the sea for ever in his ears. His father, an owner of some small vessels employed in the coasting-trade, was drowned when the boy was only five years old. Subsequently Hugh was apprenticed to a mason. Who can doubt that the environments of the boy helped to form the thoughtful, self-reliant man and the geologist?

In like manner William Pengelly, the subject of the present volume, being born at the fishing village of East Looe, in Cornwall, went to sea with his father and followed for years the life of a sailor-boy. Here, too, as in Hugh Miller's case, the surroundings of his early days doubtless helped to impart that geological bias to his thoughts, that vigour and energy to his mind and body, for which he was subsequently distinguished.

For an agreeable and instructive "Life" of this eminent man of science, the well-known Torquay geologist, we are indebted to his younger daughter, Miss Hester Pengelly. The adventures of his hardy boyhood are of necessity autobiographical. For later years his wife's letters to her mother and her invalid sister in part supply the want of a diary. His own familiar letters to his wife and children will be read with pleasure by many who care little or nothing for cave-earth or bone-beds, or the sabre-toothed tiger. Of his numerous contributions to scientific literature Professor Bonney has given a clear and appreciative notice, which forms a valuable addition to this excellent volume. The unremitting and gratuitous labour which Pengelly for many years devoted to the exploration of Kent's Cavern met with a reward of a rather unusual kind. As a poor fisher-lad he was perforce content to exchange ideas with retired smugglers and other good honest folk of that description. In mature life he was positively courted by all ranks of society, from queens and emperors down to ordinary tourists and literary men. His extremely clear, and at the same time humorous, style of lecturing won him the public ear, and the controversial interest attaching to the Cavern exploration made him for many years the man of most mark among the residents at Torquay. Of his methods of exposition one charming instance may be quoted (see pp. 231–3). Accompanied by a rustic as guide to a particular locality in Cornwall, Pengelly was searching for the Devonian fossil *Steganodictyum*, now known to be a fish. Having found a specimen, he immediately set to work with hammer and chisel, on his knees, endeavouring to extract it; whilst John exclaimed:

"'Why, what be about?'

"'Do you see this black patch?'

"'Ees, I zee it plain enough.'

"'Well, that's a fossil, and I'm trying to get it out.'

"'Oh, that's a fossil, is it? What is a fossil?'

"'Sit down, John, and I'll try to explain. Do you suppose there are any dead shells, or fish-bones, lying on the bottom of the sea yonder?'

"'Of course there is.'

"'What is the state of the river, in yonder beautiful valley, after heavy rain?'

"'Why, very muddy.'

"'When there is a very heavy gale, throwing violent waves on this cliff, does the cliff ever give way?'

"'Oh yes, there's always some part or other wasting.'

"'Very well. Now, the mud which the river brings down from the country, as well as that which the waves tear from the cliffs, finds its way to the sea, as you know, and sooner or later it settles on the bottom of the sea, and buries up such remains of dead animals or vegetables as may be lying there, and forms a new sea-bottom; on which, by-and-by, other shells, and things of that nature, will find their way; and these will be buried in their turn. Now, if this work goes on for a very long time, the mud and sand carried into the sea will form a very thick mass; and if you can suppose it to become more or less hard, it will be a rock, with remains of animals in it. And if it should from any cause get raised above the sea, the waves would begin to break it up, little by little, just as you break up the rock on which you are sitting; and after a while any person who carefully looked for them would be able to see the shells and fish-bones, and so on, that had been buried very long before, and he would call them fossils.'

"'But do you mean to say that that's the way that black thing got into the rock?'

"'Yes, that's what I mean to say.'

"'Was this rock mud once?'

"'Yes.'

"'Not made when the world was made?'

"'Oh, dear no! It was made very long since. There are rocks of very great thickness in other parts of the world, made in the same way, and some of them are much older, and others much newer, than this.'

"'Well, you *have* opened my eyes. I'll tell 'ee what 't is—I've lived longer this morning than in all the years of my life before. So that's a fossil, is it? Was it a shell or a fish-bone?'

"'There's a difference of opinion about it at present. None of them are very perfect; and some say it's a piece of sponge, whilst others think it's part of a fish.'

"'Well, never mind! 't is a fossil: let me look at 'en, and then I'll try to find some.'

"He accordingly proceeded to inspect the rocks, and in a few minutes cried out—

"'Here's one. Here's another,' and, in a short time, detected several good specimens.

"On our journey back, John asked me numerous questions, most of them very pertinent, and some of them by no means easy to answer. At the inn I betook myself to the 'parlour,' in order to greater quietude for writing. John felt himself happier in the kitchen; but, as the one room opened out of the other, I frequently heard my zealous disciple repeat to the villagers who came in from time to time—though with sundry modifications and some errors—the lecture he had heard in the morning, the invariable peroration being: 'I'll tell 'ee what 't is—I've lived longer this morning than ever I lived all the years of my life before.'"

It was not only as eyes to the blind, or in the instruction of simple and ignorant people, that Pengelly distinguished himself. His correspondence shows that he met on equal terms the leading men in his own branch of science, and especially that he was an adviser in whom Sir Charles Lyell placed a large and generous confidence. If in one of his letters to Lyell, Pengelly is made to speak of *Cheirudidæ* and *Cyphuspidæ* and of *Phacops cryptoptophatinus*, one can only hope for a speedy second edition of the book, in which these casual misprints may be corrected.

That Pengelly had many lovable traits of character, not a few of his friends would willingly testify. That he was never in opposition, never in the wrong, never out of temper, never tempted by his great abilities to exercise an imperious sway, need not be inferred from the fact that these "humanities" are not mentioned in a biography compiled with filial delicacy and tact. He was a very shrewd and sometimes an unsparing judge of the characters of other men. He was a born logician. Of his geniality it is enough to say that social gatherings at which he consented to be a guest were sure to be successful. The simplicity of his tastes, of his mode of living, and of his general demeanour, was never spoiled by the flattery, direct and indirect, of which he was so frequently the recipient. To his scientific purposes he stuck unflinchingly, and he was no less staunch to his friends.

II.—MARYLAND GEOLOGICAL SURVEY. Vol. I, 1897. 8vo, pp. 539. (Baltimore: the Johns Hopkins Press.)

THE present State Geological and Economic Survey of Maryland was established in 1896. Its objects are—(1) an examination of the geological formations of the State, with especial reference to their economic products, such as building-stones, clays, ores, and other mineral substances; (2) an examination and classification of the soils and a study of their adaptability to particular crops; and (3) an examination of the physical features of the State with reference to their practical bearing upon the occupations of the people. It was decided that these objects should be duly carried out by the preparation of maps and reports; and Dr. William Bullock Clark, Professor of Geology in the Johns Hopkins University, was happily chosen as State Geologist.

The present handsome volume is intended to serve as a preliminary account of the physiography, geology, and mineral resources of Maryland. It is well printed, and well illustrated, with excellent coloured maps and pictorial views; and we may heartily congratulate the State and the State Geologist on this first instalment of the great work which has been undertaken.

There is no doubt that in any Geological Survey organized at the public expense, the main endeavour must be to determine and to assist in developing the economic resources of the country. Such work can only be carried out by those who possess scientific training and enthusiasm; and while in all geological surveys there must naturally be a blending of pure science with applied science, it must always be remembered that the applied science is of most interest and of most importance to the community.

Professor Clark gives an instructive Historical Sketch of the progress of investigation into the physical features and natural resources of Maryland, and this is supplemented by a copious Bibliography and Cartography of the State, drawn up by Mr. E. B. Mathews. It is interesting to learn that the earliest reference dates back to 1612, while the earliest notice of certain clays and gravels was published by Captain John Smith in 1624. The mother-country can hardly go back further than this. Brickyards and iron-mines were opened during the seventeenth century; and many miscellaneous notes on minerals and other subjects were from that time published.

The first State Geological Survey was made during the years 1834–41, almost as soon as Great Britain had been induced to recognize the desirability of having an official geological survey.

ater on, from 1848 to 1862, investigations were carried on by the
ate Agricultural Chemists; and Mr. Tyson prepared a geological
ap of the State on the scale of 12 miles to an inch. As Professor
lark observes, this was "by far the most complete representation
Maryland's geology that had been attempted up to that time."
n 1887 the Experiment Station of Maryland was called into
kistence for research-work in agricultural and kindred subjects.

Meanwhile the organization of the Johns Hopkins University in
376 had inaugurated a new period of scientific activity in Mary-
nd. "The laboratories of the University were equipped for the
udy of the broadest problems of scientific enquiry. . . . .
he Geological Department was organized in 1883, when Dr. George
L. Williams began his connection with the institution as an instructor
f mineralogy. His appointment marks the beginning of a period
f investigation of the geology and mineral resources of the State
iat has been carried on by his associates and successors continuously
the present day." This period, as Professor Clark shows, has
een by far the most important in the study of the geology of
laryland. Almost from the first the members of the geological
epartment have carried on their investigations in close co-operation
ith the United States Geological Survey, and frequently as members
f its staff; and this official co-operation will be maintained. In
887 Professor Clark joined the University as instructor of strati-
raphic geology and palæontology, and his researches on the
retaceous and Eocene formations in particular are well known.

The new Survey will be based on topographic maps executed
y the United States Geological Survey, and these will be published
n the scale of two miles to an inch. As the State extends from
ie Atlantic Ocean to the crest of the Alleghanies, it comprises
great variety of physical features, of geological formations, soils,
id mineral resources. Professor Clark gives a comprehensive
itline of the present state of knowledge on these matters; and
his Table of Maryland Formations he notes Archæan, Cambrian,
ilurian, Devonian, Carboniferous, Permian (?), Triassic, Jurassic (?),
retaceous, Eocene, Neocene, and Pleistocene. The local formations
e indicated by distinctive terms such as the Juniata (red Medina),
id the Tuscarora (white Medina) in the Silurian, the Mauch Chunk
the Carboniferous, and the Pamunkey in the Eocene. After
iving an account of the numerous formations Professor Clark
evotes attention to the Mineral Resources, including Building and
ecorative Stones, Slate, Limes and Cements, Clays, Sands, Porce-
in Materials, Marls, Iron Ores, Coals, Gold, Mineral Paints,
iatomaceous Earth, Mineral Waters, Road Materials, and mis-
llaneous products. The volume concludes with a First Report
pon Magnetic Work, contributed by Mr. L. A. Bauer.

We heartily compliment Professor Clark on this successful
mmencement of his work, and more especially so as nothing which
is country has been able to issue in connection with its Official
eological Survey can compare, in its mode of presentation to the
iblic, *with this First Report* of the new Geological Survey of

Maryland. It is strange that the British Survey has always laboured under difficulties, and that its staff and equipment have been inadequate to deal with many matters of economic interest which other countries find it wise to thoroughly investigate.

III.—(1) **Beiträge zur Kenntniss der obertriadischen Cephalopoden-Faunen des Himalaya.** By Dr. Edmund Mojsisovics Edler von Mojsvar. Denkschr. d. k. Akad. d. Wissenschaften, Wien, math.-naturw. Classe, Bd. lxiii, pp. 575–701, pls. i–xxii, 1896.

(2) **Himalayan Fossils. The Cephalopoda of the Muschelkalk.** By Carl Diener. Mem. Geol. Surv. India. Palæontologia Indica, ser. xv, vol. ii, part 2, 118 pp., xxxi pls., 1895.

WHEN the older collections from the Himalayan Trias were described, species were regarded in a much wider sense than obtains nowadays; hence, before the correlation of the Indian Trias with the Triassic rocks of other countries could be attempted, it was necessary for these collections to be re-examined and fully described.

Accordingly, at the suggestion of Mr. Griesbach (now Director), the Geological Survey of India consented to send all their collections of Himalayan fossils to Professor Suess in Vienna, in order that they might be worked out by Austrian specialists. (1) The Cephalopoda were entrusted to Dr. E. Mojsisovics, who has done so much work on the Cephalopoda of the Austrian Trias; and he at once saw that by far the larger number of the specimens came from the lower portion of the Trias, and that the upper beds were represented by only a few specimens. Recognizing the scientific interest which a more detailed knowledge of the Himalayan Trias would have, in some "Preliminary Remarks on the Cephalopoda of the Himalayan Trias," which Dr. Mojsisovics communicated to the Imperial Academy of Sciences, Vienna, he advocated the sending out of a special expedition to the Himalayas to collect Triassic fossils, and indicated the more important and more promising localities at which collections should be made. Thanks to the liberal response of the Director of the Indian Geological Survey, who obtained the necessary funds from the Indian Government, and owing also to the liberality of the Imperial Academy of Sciences in Vienna, an expedition was sent out, consisting of Messrs. Griesbach and Middlemiss, of the Indian Geological Survey, and Dr. Diener, of Vienna. The expedition was made during about five months of the year 1892, and proved very successful, extensive collections being made. These were also sent to Vienna, and the Triassic Cephalopoda contained therein form by far the greater part of the material which is described in the present memoirs. The Upper Triassic forms have been dealt with by Dr. E. von Mojsisovics, whilst Dr. Diener himself has described the fauna of the Muschelkalk, and will describe also that of the Lower Triassic rocks.

The first discovery of Triassic fossils in the Himalayas is due to Captain (now Sir Richard) Strachey, who communicated an account of his geological discoveries in the Himalayas to the Geological

Society of London in 1851. Professor Suess, who saw these specimens during a visit to London, recognized the Alpine character of some of the fossils, and even went so far as to identify some of them with species which had already been described from the Alps. In 1863, in his description of Dr. Gerard's collection of fossils from the Spiti valley, H. F. Blanford described two Triassic Ammonites, and observed that the Triassic specimens were not sufficiently numerous to lead him to infer the existence of a distinct formation of that age; he stated, however, that the investigations of Mr. Theobald, who had just returned from a visit to the Spiti valley, established the existence there of Triassic rocks, as well as rocks of Silurian and of Upper Oolitic age. In this same year Oppel began his important memoir on the fossils collected by the brothers Von Schlagintweit in Tibet and Spiti during the years 1854–7; and, although the collectors did not state the geological horizon at which the fossils had been obtained, Oppel inferred, from an examination of the specimens, that they had not all been found in the Spiti Shales, and some two years later he assigned a number of them to the Trias. In 1864 Professor Beyrich described a couple of fragments of Triassic Ammonites which had been brought from Ladakh. Salter, in his description of Strachey's Triassic fossils which appeared in the following year, regarded them as of Upper Triassic age; Dr. Diener, however, states that most of the Cephalopods that he described belong to the Muschelkalk, and that the few real Upper Triassic forms that he identified with European species were not correctly determined. In the same year, from an examination of the brachiopods and bivalves of the Schlagintweit collection, Gümbel came to the conclusion, not only that rocks of Triassic age were present in Spiti, but that two horizons could be recognized, an upper and a lower; the former he regarded as the equivalent of the European Muschelkalk, and the latter as comparable with the Werfen beds of the Alpine Trias.

In his memoir on the Cephalopoda of the Alpine Muschelkalk, Professor Beyrich pointed out that most of the Triassic Ammonites described by Oppel were more nearly related to species from the Muschelkalk than to Upper Triassic forms, and he considered that a great portion, at least, of the Triassic deposits of the Himalayas should be regarded as homotaxial with the Alpine Muschelkalk. Stoliczka, however, who visited Spiti in 1864, believed that only Upper Triassic rocks were present, and that representatives of the rest of the Triassic rocks were entirely wanting in this part of the Himalayas; nor did he consider that their presence had been proved in any other portion of these mountains, an opinion which he still maintained after a subsequent visit to these regions. Griesbach, on the contrary, after a visit to Niti, stated that there "the whole Trias, from the Alpine Werfen beds (Buntsandstein) to the Upper Keuper rocks," was present. After an examination of all the Triassic Cephalopoda in the Museum of the Indian Geological Survey at Calcutta, including Stoliczka's type-specimens, Dr. Diener considers that probably only two species are undoubtedly of Upper Triassic age, two others *being* somewhat doubtful, whilst all the rest are characteristic forms of the Indian Muschelkalk. That the Himalayas do contain, not only Upper Triassic rocks, but beds both of Muschelkalk and of Lower Triassic age, there is now no doubt; in fact, they contain the richest development of the Lower Trias that has hitherto been discovered.

In the Cephalopod fauna of the Upper Triassic rocks here described the Nautiloids are represented by the genera *Pleuronautilus*, *Nautilus*, *Clydonautilus*, and *Orthoceras*, and the Dibranchiates by some phragmocones of *Atractites*; but by far the larger portion of the fauna consists of Ammonoids. In addition to Himalayan forms Dr. Mojsisovics also describes and figures a new *Didymites* (*D. afghanicus*) from Afghanistan, and an indeterminable species of *Stenarcestes* from New Caledonia. Several new genera and subgenera are proposed; and altogether seventy species are described as new and are named, whilst many forms which are regarded as new the author considers to be too imperfectly known to be named. So minutely is the fauna described that it amounts almost to the description of individual specimens, for of the seventy new species that are described thirty-three are based upon single specimens. All the species are exceedingly well-figured on the twenty-two plates accompanying the memoir. Dr. Mojsisovics arranges in a tabular form the different zones that he has been able to identify in the Indian Trias Province, and indicates their relation to the zones that have been established in the Mediterranean Trias Province. He considers that the fauna of the Indian Province, although distinct from that of the Mediterranean Province, shows that there was during the Upper Trias period a sea connection between the two regions; the Mediterranean Province was, in fact, the westerly extension of the great Triassic sea—named by Professor Suess the Thetys—which occupied the present mountainous regions of Asia, extending in an easterly direction as far as the present Pacific Ocean. The author concludes his memoir with some interesting remarks on the sea of the Triassic Period.

(2) Dr. Diener divides his memoir into two portions, the first part dealing with the Muschelkalk fauna of the main region of the Central Himalayas, the second being devoted to that of the Triassic limestones of Chitichun, to the north of the main region. In the fauna of the main region the Nautiloids are represented by the genera *Nautilus* and *Orthoceras*; the Dibranchiates by the genus *Atractites*; and the Ammonoids by the genera *Ceratites*, *Danubites*, *Japonites*, *Acrochordiceras*, *Sibirites*, *Isculites* ?, *Proarcestes*, *Lobites* ?, *Meekoceras*, *Gymnites* (with the new subgenus *Buddhaites*), *Sturia*, and *Ptychites*. Thirty-two new species are described; nineteen are founded upon single specimens, fifteen of which are stated to be in the author's collection, whilst of the thirteen species founded on more than one example, in six cases all the examples of the species are also in the same collection. Dr. Diener agrees with Dr. Mojsisovics in regarding the Muschelkalk fauna of the central region of the Himalaya as a connecting-link between that of the Arctic-Pacific on the [illegible] and that of the Mediterranean on the other, but points out

that it contains a considerable number of forms which are peculiar to it, and impart to it the character of a zoo-geographical region of its own.

The Muschelkalk of the main region of the Central Himalayas is divisible into two portions: the lower ranges from three to six feet in thickness, and is characterized chiefly by a Brachiopod fauna; the upper has a thickness of from 15 to 40 m. or from about 50 to 130 feet, and has yielded a very rich Cephalopod fauna. Dr. Diener says that "so far as such palæontological analogies may be permissible in correlating formations geographically so widely separated, we may consider the main mass of the Himalayan Muschelkalk to be an equivalent of only the Upper Alpine Muschelkalk of the Mediterranean Triassic province."

Nowhere in the Himalayan Trias have deposits of Norian and Lower Carnian Age been met with between the Muschelkalk and the *Daonella*-beds, the uppermost bed of the Muschelkalk being conformably overlain by a limestone yielding an *Aonoides*-fauna. Hence it would seem that possibly the Indian Muschelkalk is the homotaxial equivalent of the Muschelkalk and of the Norian stage of the Mediterranean Province, but Dr. Diener considers that our present knowledge of the palæontological evidence does not justify us in this conclusion.

The Triassic limestone of Chitichun occurs only in detached blocks, and is lithologically entirely different from the Triassic beds of the main region. Dr. Diener regards its fauna as of Muschelkalk age, but belonging to a somewhat lower horizon than that of the main region of the Central Himalayas.

Both memoirs are illustrated by numerous excellent plates, and form a most important contribution to our knowledge of the Indian Triassic Cephalopoda. We look forward with interest to Dr. Diener's work on the rest of the Triassic Cephalopoda of these regions.

IV.—The Geology of the Country around Liverpool, including the North of Flintshire. With Appendix and Geological Map of the District. By G. H. Morton, F.G.S., etc. New Edition. 8vo; pp. 319, with 22 Plates and 15 Woodcuts. (G. Philip & Son: London and Liverpool, 1897.)

As a veteran resident geologist, the author has long been accustomed to note and collect everything remarked by himself and others about his favourite subject of research, namely, the geological history of the district within a radius of about twenty miles around Liverpool, but for the most part limited to places within about twelve miles. The first edition of this work, issued in 1863, was reviewed in *The Geologist*, vol. vi, p. 478; the second edition was reviewed in the Geological Magazine, Dec. III, Vol. VIII, p. 226. The present edition begins with a reprint of the "Preface to the Second Edition," dated 1891; and the "Preface to the Appendix," at p. 291, accounts for the additional six years in which much local information has accrued for the production of this "New Edition" (1897).

A list of the *principal* works and papers on the geology of the neighbourhood of Liverpool, from September, 1890, to the end of 1896, comprises thirty-three papers, chiefly published in the Proceedings of the Liverpool Geological Society, the source also of a large proportion of the material referred to in the former editions, for which a bibliography would have been highly useful. The memoir last quoted in the list is Mr. Morton's condensed account of the geology of the district under notice, prepared as a handbook for the British Association Meeting in 1896, and accompanied with a geological map based on the Geological Survey Map, Sheet 79, N.E., and portions of the adjoining sheets, so as to include the Coal-measures lying to the north-east of Liverpool. Some details of the National Map, such as the actual coal-seams and faults, which are often the boundaries of the exposed formations, are omitted; and some important patches of the Red or Keuper Marl have been introduced. If the colours on the map and its index had been numbered with successive figures, there would have been less difficulty in recognizing the several faint tints of red and pink.

The corrected list of the Formations and their estimated thicknesses in South-West Lancashire, including Wirral (the large peninsula south-west of Liverpool, between the Mersey and the Dee), and of North Flintshire, is as follows:—

SOUTH-WEST LANCASHIRE AND WIRRAL.

			FEET
Recent		Blown Sand and Estuarine Sand and Silt	100
Pleistocene	Post-Glacial	Peat and Forest Beds, Silt and Sand	25
	Aqueo-Glacial	Boulder-clay and Sand	100
	Pre-Glacial	Cave-deposits (in Flintshire and Denbighshire)	2
Trias	Keuper	Red Marl	1000
		Keuper Sandstone	400
	Bunter	Upper Soft Sandstone	550
		Upper Hard Sandstone	400
		Lower Hard Sandstone (with pebbles)	600
		Lower Soft Sandstone	400
Permian		Magnesian Limestone	10
		Marl and Soft Sandstone	100
Carboniferous	Coal-measures	Upper Coal-measures	1200
		Middle or Productive Coal-measures	1300
		Lower Coal-measures	1880
	Millstone-grit	Millstone-grit	300
			8,367

NORTH FLINTSHIRE.

Carboniferous	Coal-measures	Middle or Productive Coal-measures	700	[1]
		Lower Coal-measures	300	
	Cefn-y-Fedw Sandstone	Gwespyr Shale	150	
		Gwespyr Sandstone	120	
		Holywell Shale	100	
		Cherty Sandstone (with shale)	250	
	Carboniferous Limestone	Upper Black Limestone	200	
		Upper Grey Limestone	500	
		Middle White Limestone	600	
		Lower Brown Limestone	400	
		Red Basement-beds	3	
			3,323	

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[1] These are represented in South-West Lancashire by the Middle and Lower Coal-measures and Millstone-grit.

Not much has been added to our knowledge of the local Coal-measures, the Permian, and the Bunter Sandstone. Permian fossils, however, have lately been found by Mr. E. Dickson at Skillaw Clough, near Parbold, namely: *Gervillia antiqua*, *Mytilus squamosus*, *Pleurophorus costatus*, *Schizodus obscurus*, and *S. rotundatus* in the purple shales, and *S. Schlotheimi* in the limestone; thus adding to the late Mr. E. W. Binney's fossils from the same limestone, and confirming Dr. E. Hull's discovery of the Formation in that district.

The Red Keuper Marl has been proved to have a much greater thickness than was formerly supposed, being 1,000 instead of 400 feet; the whole thickness of the Liverpool Trias is now calculated at 3,350 feet (p. 297). In the equivalents in Cheshire of the Bunter Pebble-beds of the Midlands, the pebbles occur only scattered in the lower 600 feet, and are altogether absent in the upper 400 feet. Hence these cannot be well termed Pebble-beds; and Mr. Morton has replaced that name, as far as his district is concerned, by the "Upper" and the "Lower Hard Sandstone."

At Bidston, in Wirral, a boring has been made to the depth of at least 2,850 feet; but the characteristics of the several strata are not known, the particulars having been withheld by the promoters. Some brine was met with, but no coal, though it was expected to have been found at 2,000 feet, according to the calculated thickness of the Triassic beds in the locality. Probably a local depression of the Coal-measures was met with there.

At page 299, Mr. Morton explains that he has now reason to believe in there being six kinds of fossil footprints in the Keuper Sandstone at Storeton and elsewhere, which he here names, describes, and figures, namely:—

Chelone rotundata, Morton, pl. xii, fig. *d*.
Cheirotherium (known also as *Labyrinthodon* and *Cheirosaurus*)
    Storetonense, Morton, pls. viii–xi. The trail of the animal's tail [or body (?)] is figured on pl. xxii.
C. minus, Morton, pl. xxi, figs. *a* and *b*.
Rhynchosaurus articeps, Owen, pl. xii, fig. *a* (three largest).
R. minimus, Morton, pl. xii, fig. *c*.
R. tumidus, Morton, pl. xii, fig. *a* (two smallest).

Equisetites Keuperina, Morton, p. 115, pl. xii, fig. *f*, is another fossil named by Mr. Morton. It was determined by Mr. F. M. Webb in or before 1891.

Lists of characteristic fossils are given for the different formations successively described in detail, with the necessary sections, from the lowest upwards, throughout the volume. This book is invaluable to those who have, either persistently or incidentally, to study the physical features, the geological structure, the products, and the capabilities of the country. The changes which the surface, from the earliest times, whether along the coasts, or in the river-valleys, or on the more elevated grounds, has undergone from the action of the air, water, or ice, enlarge the field of inquiry for the physicist; and their study is a source of pleasure to the scientist, whether professional or amateur.

Mr. Morton has continued to add to the general stock of knowledge on all these points; and the Appendix (pp. 293–319) indicates, among other things, an extended acquaintance with ice-scratched surfaces at and near Liverpool. These local "glacial striæ" were more probably (p. 302) made by "bergs and pack-ice," "brought by the wind and tides from the north and north-west over the low-lying Triassic rocks of South-West Lancashire and Wirral," than by "the action of an enormous glacier, of which there is no probable evidence." Further notes and particulars about the erosion on the coasts, especially at the Leasowe on Wirral, are communicated; as well as the results of Mr. Morton's careful research as to the range of species in the Carboniferous Limestone of North Wales.

T. R. J.

V.—Appendix to the Geology of the Country around Liverpool, with a Geological Map of the District. By G. H. Morton, F.G.S. 8vo, pp. 293–319. (Liverpool: George Philip and Son, 1897. Price, 4*s*. 6*d*.)

THIRTY-FOUR years have passed since the first edition of Mr. Morton's well-known work on the Geology of Liverpool was published. A second edition was issued in 1891, and now the more recent researches have rendered desirable an Appendix. The map, which is printed in colours, shows very clearly the distribution of the various formations, exclusive of the mantle of Glacial Drifts. It is based on the work of the Geological Survey, but contains important additions and revisions. The term "Pebble-beds" of the Bunter is replaced by that of the Upper and Lower Hard Sandstone, because in Cheshire and South-West Lancashire scattered pebbles only occur in the lower beds, and they are absent altogether from the upper portion of the series. The total thickness of the Keuper Marl is now known to be 1,000 feet. Three plates illustrating remains of *Cheirotherium* are added. The author gives further notes on the range of species in the Carboniferous Limestone of North Wales; and he contributes particulars relating to the erosion of the sea-coast, glacial striæ, and recent deep borings.

VI.—Florentino Ameghino. La Argentina al través de las Últimas Épocas Geológicas. Disertación pronunciada en el acto de la inauguración de la Universidad de La Plata (18 de Abril de 1897). (Buenos Aires, 1897.)

THE present lecture, delivered on the day of the inauguration of the La Plata University, covers the same ground as a former paper by the author, of which a translation was published in this Magazine;[1] so that Mr. Smith Woodward's remarks accompanying the translation apply on the whole to the present paper as well. What is new are the text-figures, accompanied by very short characteristics of the oldest hitherto known Mammalian fauna of Argentina, from the *Pyrotherium*-beds. The figures are taken from the author's forthcoming memoir in vol. xviii of the *Boletin del*

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[1] Geol. Mag., Dec. IV, Vol. IV, 1897, pp. 4-23.

Instituto Geografico Argentino, which will contain a full description of these "Cretaceous" Mammalia.

What is before us for the present certainly shows that the fauna of the *Pyrotherium*-beds possesses a somewhat more archaic facies than the one from the Santa Cruz beds. This is especially seen in the teeth, which throughout the groups are no more rootless, but have long roots with comparatively short crowns. But, apart from this, all the forms appear to be still so much specialized, that the author will probably stand alone in assigning this fauna to the UPPER CRETACEOUS.

One thing is certain; we have to do with more ancient types than those of the Oligocene of Europe, from which some European palæontologists would derive the fossil Mammalia of Argentina, *à travers* the African continent. In several forms we see an approach to the Lower Eocene, Puerco fauna, of North America. *Notostylops,* for example, has as many claims to be a primitive Edentate as some of the Puerco fossils recently described by Dr. Wortman. The relation to the Puerco fauna is acknowledged by Señor Ameghino himself, when assigning several forms to the Phenacodontidæ and Periptychidæ, "the oldest representatives of the Condylarthra."

What the author's reasons are for considering the Primates of these *Pyrotherium*-beds as the ancestors alike of extinct and recent lemurs and of monkeys, cannot be seen from the paper before us. What strikes us in the figures, notably of *Notopithecus* (p. 4), is the mode of abrasion of the teeth, quite unusual for Primates, and leading to the supposition that these creatures were neither insectivorous nor frugivorous.

Of Rodentia very little is said in the present lecture; from the former paper we learn that they were provided with *two* premolars. If these Rodents are really hystricomorphous, this character alone would justify us in considering them as the forerunners of the Tertiary "hystricomorphous" Rodents of Europe, and not vice versa.

The figures intercalated in the text seem to be accurate as far as they go; but they are insufficient, being mere pen-and-ink sketches, such as a travelling palæontologist would sketch in his notebook.

On the whole, this preliminary notice of the *Pyrotherium*-beds fauna is just sufficient to satisfy the curiosity of the naturalists at large, and to excite in the highest degree the curiosity of the specialist. For a fuller knowledge of the characters of this fauna, we have to await the publication of the promised Memoir.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

The first meeting of the session 1897–8 took place on November 3, 1897. Dr. Henry Hicks, F.R.S., President, in the Chair.

The President read a letter received from the Secretary of State for the Home Department conveying Her Majesty's gracious reply to the Congratulatory Address submitted to her, on the occasion of the Sixtieth Anniversary of her Accession, by the President, Council, and Fellows of the Society.

The Secretary announced that Lady Prestwich had presented to the Society a half-length portrait, in oils, of the late Sir Joseph Prestwich, painted by Mr. W. E. Miller.

Mr. W. W. Watts proceeded to give details of some interesting geological features recently exposed at the new Sewerage Works at Carshalton, Surrey, now being made by the Urban District Council, to which the attention of the Society had been directed by the Surveyor during the autumn recess.

These excavations are situated at a spot which on the Geological Survey Map is coloured as London Clay; and the features of the ground fully justified this colouring. The excavations, however, have shown that there are loamy and sandy beds of a light-yellow colour, some 14 or 15 feet in thickness, and apparently occupying a hollow in the London Clay. At the base these sandy beds become dark and clayey in some places, and include flints and pebbles, while below this is the London Clay. In the dark pebbly layer were found a large skull, a piece of a tusk, and a number of smaller bones, which Mr. E. T. Newton has determined to be a piece of elephant tusk, the skull (31 inches long) of *Rhinoceros antiquitatis* with some of its limb bones; while the smaller bones represent two or perhaps three horses. Although the teeth of the rhinoceros are wanting, the skull is otherwise very perfect; and, bearing this in mind, as well as the fact that certain of the limb bones were also found, and that *Elephas* is represented by the tusk, and all three (it is said) at a depth of 14 or 15 feet, little room is left for doubting that we have here at Carshalton a Pleistocene deposit of a somewhat unusual character and at a spot where it was not before suspected.

Mr. Whitaker, who was responsible for the geological mapping of this district, pointed out how the general configuration of the district gave no clue to the presence of this deposit of loamy sand, which occurred on a gentle slope, and that even now it was only possible to mark it on the map as an oval patch round the excavations with uncertain boundaries. The Drift shown, moreover, differs from that of the neighbourhood in that the latter is essentially gravel, while the former is sand, with loamy beds, but, as a rule, not stony, so that there are no surface indications of gravel.

The mammalian remains are now preserved in the Museum of Practical Geology through the kindness of the District Council.

Lieutenant-General McMahon, V.P.G.S., having taken the chair, the President made a communication regarding very similar deposits to those above described occurring in North-Western Middlesex. Some years ago he described sections in Glacial Drift on the Hendon plateau exposed during sewerage operations. More recently the sewers have been carried on at lower levels between Hendon and Edgware, and numerous remains of the mammoth and rhinoceros have been found resting on an eroded surface of London Clay, and covered over by about seven feet of stratified sands, gravels, and brickearth. These deposits were found to spread out for considerable distances over the plain, and to be cut through also by the Silke stream, a tributary of the Brent. This area has hitherto been supposed to consist almost entirely of London Clay, but the sections have now shown that the brickearth, which in many respects simulates the London Clay, is underlain by deposits which must be classed as of Pleistocene age.

The President then resumed the chair, and Mr. H. B. Woodward called attention to a block of quartzite from Criccieth, in Carnarvonshire, which had been sent for exhibition by Mr. G. J. Day. The rock contained a band of disrupted clayey material which presented on the surface of the block a rude resemblance to hieroglyphics. He thought that the curious structure had been produced on a seashore bounded by clay cliffs, where a film of mud had been spread over the sands; and that the mud had dried and curled up before other layers of sand had been accumulated on the top of it. Similar phenomena might be produced at the present day on the Cromer coast, where thin films of mud were in places spread over the sands of the seashore. It had been suggested that the appearances in the Criccieth stone might have been produced in the original deposit during the irregular solidification of the sand and its included layer of mud. The rock itself was regarded by the President as probably derived from the Harlech Grits, in which he had observed somewhat similar features.

Mr. Bauerman, as one of the three Delegates appointed by the Council on behalf of the Society to attend the recent International Geological Congress, held at St. Petersburg, gave a short account of the work of the Congress, dwelling more particularly on the excursion to the Ural Mountains, in which he had taken part.

The following communication was read:—

"A Contribution to the Palæontology of the Decapod Crustacea of England." By the late James Carter, F.R.C.S., F.G.S. (Communicated by Professor T. McKenny Hughes, M.A., F.R.S., F.G.S.)

This paper deals mainly with the Brachyura. The author describes several new species, belonging to the genera *Nephrops*, *Gebia*, *Homolopsis*, *Ranina*, *Mithracia*, *Neptunus*, *Actæposis*, and *Goniocypoda*. The genera *Gebia*, *Ranina*, and *Neptunus* have not been previously recorded from British rocks. *Diaulax* is for the first time identified from the Tertiary strata — a single specimen having been found in the Middle Headon. *Platypodia Oweni*, Bell, is now referred to the genus *Diaulax*; and *Palæocorystes Broderipi*, Bell, to the genus *Eucorystes*.

As a result of the careful study of large series of specimens in various collections, the author is able to give much additional information concerning the morphology of several species.

CORRESPONDENCE.

SCANDINAVIAN ICE AND NORFOLK DRIFT.

Sir,—In the article which appeared in the October number of the Geological Magazine, I called the attention of Sir Henry Howorth to the evidence for the former presence of an ice-sheet blocking the North Sea during the period of maximum glaciation, based on the deflection of the ice-striæ along the eastern coast of Scotland. Owing to that article having been written during my holiday in Norfolk, and in the absence of the numbers of the Magazine previous to that of August, I had overlooked the fact that Sir H. Howorth had dealt with this problem in the April number of the Magazine, and had deliberately rejected the hypothesis. I now ask for permission to express my regret for this oversight.

While on this subject, may I be allowed very briefly to state the conclusions regarding the mode of formation of the Drift of North Norfolk, at which I have arrived from an examination of the sections along the coast and inwards about Cromer and Sherringham. I now altogether abandon the view which I had held before this visit—that the Drift deposits owe their origin to an ice-sheet stretching from Scandinavia across the North Sea; and to this extent I find myself in agreement with Sir Henry Howorth and Mr. F. W. Harmer, who reject the ice-sheet theory as applied to this part of England.[1] As regards the Boulder-clay laid open for miles along the coast, we have a formation fairly uniform in character, distinctly laminated, and not excessively laden with erratic stones and boulders. This is not the kind of deposit we should expect from an ice-sheet, nor does it bear a resemblance to the Till (or Lower Boulder-clay) of the north-west of England and Scotland. It appears to me to be a distinctly aqueous deposit, resembling (except in colour) the Upper Boulder-clay of that region. What I believe I did see in these cliff-sections was a deposit precipitated over the floor of the sea in muddy waters, fed by glacier rivers, crowded with ice-floes and bergs, from which the erratic blocks fell down and became imbedded in the soft mud. Larger bergs of ice were also present, piloting along those huge masses of chalk such as are seen on the coast-section east of Cromer. Such conditions as the above would explain the occurrence of blocks and stones derived from various sources. The overlying "Interglacial sands and gravels" are also clearly marine deposits, but laid down in shallower waters than those of the Lower Boulder-clay, waters generally clear and free from muddy sediment. The manner in which the gravels rest on an eroded surface of the Boulder-clay shows that the sea-bed had become very shallow, and that changes in the physical conditions of sea and land had taken place; the change in the character of the deposits being sharp and decisive. These beds of stratified sand and gravel reach a level of 320 feet at the "Roman camp" above Upper Sherringham, giving the minimum amount of the submergence at this epoch and in this part of East Anglia. EDWARD HULL.

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[1] "On the Pliocene Deposits of Holland": Q.J.G.S., November, 1896, p. 775. Mr. Harmer says: "It is difficult to see how the Baltic Glacier could have reached East Anglia, though ice-floes with Scandinavian boulders might easily have done so."

OBITUARY.

REV. PROFESSOR HAUGHTON, D.C.L., F.R.S., F.G.S.

BORN 1823. DIED OCTOBER, 1897.

AT the close of the month of October last there passed away, in his 75th year, one of Ireland's most eminent sons, whose name stands at the head of this notice, and who must have been well known to many readers of the GEOLOGICAL MAGAZINE. The late Dr. Haughton came of a Carlow family, and at an early age entered Dublin University, of which he afterwards became so distinguished an ornament. Graduating in 1844, he took the senior mathematical moderatorship and gold medal, and in the same year obtained his Fellowship at the first trial; a performance almost unique in the history of the University. Those only who know what a tremendous test of mathematical and classical knowledge the examination for a Fellowship in Trinity College really is, can fully realize the greatness of this mental achievement.

The writer well remembers the first time he saw Haughton. The examinations for "littlego" were about to commence, and we were all seated at our desks waiting for the distribution of the papers, when a side door opened, and Jellett (afterwards Provost) and Haughton entered together. Both were in the prime of youth and vigour, both had reached the goal of Fellowship ; and the writer was struck by the extreme beauty of countenance exhibited by the former, and the quick glance and decisive step of the latter, indicative of the restless activity of the mind within.

Most men in attaining a similar position elect to devote their time and talents to the cultivation of one branch of "natural knowledge" or research. It was otherwise with Haughton. His avidity for investigation in many directions was insatiable, and there were few subjects which he did not study in turn. His mind had essentially a mathematical bent, but he had also a strong leaning in the direction of physical and biological subjects. Hence he studied chemistry, geology, physical geology, and biology, with never-tiring devotion, and thus qualified himself for the great work he had kept in view—the development of the range of subjects to be taught in the University curriculum. Two years after obtaining the Fellowship he entered Holy Orders, and in 1847 was appointed Assistant Divinity Lecturer. But Divinity was not Haughton's strong point. The University School of Medicine was the object upon which he had determined to concentrate his energies, in order to its development and greater usefulness. With this object in view he studied medicine and surgery, taking the degrees of M.B. and M.D. in 1862. Thus fully equipped by this course of study, he proceeded to reorganize the Medical School, and being liberally supported by the Provost and Board with funds, additions were made to its buildings and equipments. A new chemical laboratory (now under the direction of Professor Emerson Reynolds) was built, and a spacious anatomical museum was erected and well furnished with typical specimens for the use of students. Thus provided with all appliances, and with the objects of practical study afforded by the Dublin Hospitals, it is not surprising that the Dublin University Medical School ranks second to none amongst the institutions of this kind in the British Islands.

Nor did Dr. Haughton neglect original investigation into many curious problems of natural history. As Secretary to the Zoological Gardens in the Phœnix Park, Haughton had many opportunities for studying the habits of the inmates; and one of the most remarkable of his experiments was that by which he endeavoured to determine the relative strength of the lion and tiger. The writer cannot find an account of this experiment in "The Principles of Animal Mechanics," and has to depend on his memory alone. As far as he recollects, the trial was tested by the number of men hauling at a rope required to pull the fore-paw of each animal through the cage against its will. The experiment was decided in favour of the tiger, so that "the king of beasts" was dethroned from his position of eminence. A more important series of experiments was that on the muscular strength carried out by measurements of the cross-section of the muscles of various animals, resulting in the general proposition that "the work done by the contraction of a muscle is proportional to its length and area of cross-section conjointly."[1] These experiments, like most of those undertaken by Haughton, were worked out by accurate mathematical formulæ.

To geologists, the investigations which were of greatest interest, were contained in his papers on the Irish granites, in which he was able to show by chemical analyses that in each granitic region (and of these there are four) there are representatives of the soda and potash varieties.[2] At the time these papers were published, microscopic analysis had not come into use; and although more recent observers, with the aid of thin sections under the microscope, have examined these rocks, it has not been shown that Haughton's conclusions can be shaken. Another interesting set of observations were those carried out by Dr. Haughton and the writer on the Vesuvian lava-streams from specimens ranging throughout a period of 237 years (from 1631 to 1868), which resulted in showing that both in chemical composition and mineral structure no important change had taken place throughout this period.[3]

Besides his numerous contributions to the transactions of learned societies, Haughton, in concert with his friend and colleague, the late Rev. J. Galbraith, brought out a series of textbooks, designed chiefly for students, which had a wide circulation, and were known as "Galbraith and Haughton's Manuals." These dealt with the following subjects: "Euclid," "Plane Trigonometry," "Mathematical Tables," "Mechanics," "Optics," "Hydrostatics," "Tides," "Astronomy," "Steam-Engine," "Algebra," and "Arithmetic." The publication of these Manuals gave rise to the following parody, taken from David's lament over Saul and Jonathan: "Galbraith and Haughton were beautiful in their lives; and in their Manuals they were not divided!" In 1865, however, Haughton published a Manual of Geology, by himself; Longmans and Co., 8vo, pp. 360 (see GEOL. MAG., Vol. II, 1865, p. 449).

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[1] "Principles of Animal Mechanics," p. 443.

[2] Q J G.S., vol. xii, pp. 171, 188; and vol. xiv, p. 300.

[3] Trans. Roy. Irish Acad., vol. xxvi (1876).

Other works were the "Principles of Animal Mechanics," a book of extreme interest and originality, published in 1873, and "Six Lectures on Physical Geography" (1880). Meanwhile, well-merited honours were falling thick and fast on Haughton. In 1853 he was elected a F.G.S., and F.R.S. five years later (1858). He filled the offices of President of the Royal Irish Academy and of the Royal Geological Society of Ireland. Oxford conferred upon him the honorary degree of D.C.L. in 1868, and Cambridge followed suit a few years later, in 1880, while Edinburgh added her LL.D. in 1884; and that he was the life and soul of many Dublin societies and institutions, need scarcely be said.

Of Haughton's personal character little need here be stated. He was a general favourite with those who knew him; and when he rose to speak in public his trenchant manner of dealing with his subject, combined with an overflowing fund of humour, sometimes spiced with sarcasm, at once rivetted attention. In advocating or opposing a cause he was absolutely fearless of persons or of outside opinion, and undoubtedly he exercised great influence in the government of Trinity College. Those who, like the writer, were sometimes in his company at the dinners of the Dublin Geological Club, are not likely to forget the unfailing flow of wit and anecdote which kept the company in a state alternating between delight, amusement, and, it must be added, sometimes horror! In literature the *Noctes Ambrosianæ* of Professor Wilson afford the only parallel. E. H.

PROF. CONSTANTIN BARON VON ETTINGSHAUSEN.

BORN 1826. DIED FEBRUARY 1, 1897.

THE Baron CONSTANTIN VON ETTINGSHAUSEN, who was born at Vienna in 1826, and died at Graz on the 1st February of this year, shares with Heer and Saporta the merit of having, more than any other workers, advanced our knowledge of the Fossil Flora of the Tertiary period. This was the chief, although not the exclusive field of his astounding activity, which extended over a period of forty-seven years, from 1849 to 1896.

He graduated as a Doctor of Medicine in Vienna, beginning his scientific work almost immediately afterwards. After having been for a few years an Assistant in the Geologische Reichsanstalt, he became Professor at the Medical and Surgical Military Academy at

Vienna, the "Josephinum," which post he occupied from 1854 to 1871. In the latter year he received a call, as Professor of Botany and Palæophytology, to the University of Graz, where he remained until his end.

Most of his contributions to science are embodied in the publications of the Vienna Academy, notably the extensive Memoirs on the Tertiary Floras of Bilin, Sagor, Parschlug, Schönegg, Radoboj, Leoben, and others. Besides, he contributed papers to the Proceedings of the Royal Society of London on the Floras of Sheppey and of Alum Bay; and to the Palæontographical Society of London, the first volume of "A Monograph of the British Eocene Flora" (1879), in collaboration with Mr. J. Starkie Gardner. Other papers, chiefly on the Fossil Flora of Australia and New Zealand, are to be found in the GEOLOGICAL MAGAZINE, in the Quarterly Journal of the Geological Society, in the Memoirs of the Geological Survey of New South Wales, and in the Transactions and Proceedings of the New Zealand Institute.

Several collections brought together by Baron Ettingshausen are exhibited in the Geological Department of the British Museum; and at the end of the Seventies and later on, he made several lengthened stays in London, occupied with the rearrangement and critical examination of parts of the Phytopalæontological Collections in our National Museum.

Of him was said in 1884—"Coupled with his great powers of accurate observation and strictly scientific method of investigation, Ettingshausen displays an unusually broad grasp of the deeper problems which palæobotany presents, and has undoubtedly been for many years far in advance of all his contemporaries in this field in correctly apprehending and announcing the true laws of phytochorology and plant development."[1]

THE REV. P. B. BRODIE, M.A., F.G.S.

BORN 1815. DIED NOVEMBER 1, 1897.

THE REV. PETER BELLINGER BRODIE, M.A., F.G.S., whose life we recorded among our "Eminent Living Geologists," in the November number of this Magazine (pp. 481–485), passed peacefully away on the 1st November, at his residence, Rowington Vicarage, near Warwick, in his 82nd year. The notice of his life and his portrait, which appeared in our last monthly issue, tell all we have to record of this most excellent man and geologist. He was a Fellow of the Geological Society for sixty-three years. His memory will be warmly cherished by a wide circle of friends and geologists, many of whom he led on and encouraged by his enthusiasm to take up the hammer and join the ranks as field-naturalists and fossil-collectors in Warwickshire and elsewhere.

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[1] Lester F. Ward, "Sketch of Palæobotany": 5th Ann. Rep. U.S. Geol. Survey to the Secretary of the Interior, 1883–4, p. 380. Washington, 1885.

INDEX.

ACANTHONAUTILUS ***bispinosus***, Foord, gen. et sp. nov., 147, 287.
Acanthoteuthis speciosa, Münster, 1.
Adams, F. D., Structure and Origin of certain Rocks of the Laurentian System, 516.
Adams and Nicholson, Experiments on the Flow of Rocks, 513.
Æpyornis *Hildebrandti*, Skeleton of, 241.
Age of the Earth, Geological Evidence regarding the, 415.
Age of the Morte Slate Fossils, 59, 105, 191, 236.
Age of the Rand Beds, 548.
Age and Structure of the Gneissose-Granite of the Himalayas, 304, 345.
Allport, Samuel, Obituary of, 430.
Ameghino, F., On the Geology and Palæontology of Argentina, 4; *Pyrotherium*-beds, 568.
America, South, Fossil Entomostraca from, 259, 289.
Ancient Volcanoes of Great Britain, 326, 371.
Andrews, C. W., On the Structure of the Skull of a Pliosaur, 92; On a nearly complete Skeleton of *Æpyornis*, 241.
Anglesey, Origin of some of the Gneisses of, 237.
Annesley to Rugby, Geology of Railway from, 49, 98.
Annual General Meeting of the Geological Society, 180.
Annual Report of the Geological Commission of the Cape of Good Hope, 524.
Annual Report of the Geological Survey of the United Kingdom, 233.
Antrim, The Cretaceous Strata of the County of, 332.
Apiocrinus recubariensis, Crema, is a Primitive *Millericrinus*, 116.
Association of *Sigillaria* and *Glossopteris* in South Africa, 235.
Augite-Diorites with Micropegmatite in Southern India, 330.
Australia, The Dry Lakes of Western, 363.

BALTOCERAS, A new Genus of the Orthoceratidæ, 251.
Bather, F. A., On *Apiocrinus recubariensis* from the Muschelkalk, 116; *Hapalocrinus Victoriæ*, n.sp., from the Silurian, Melbourne, 338; On *Scolocystis*, *Echinocystis*, and *Lysocystis*, 381.
Beach Sand and Shingle, Movements of, 44.
Bell, D., The Great Submergence, 27, 63; High-level Shelly Clays, 189.
Bennett, J. F., On the Origin of Lynchets, 379.
Bennettites, *Williamsonia*, and *Zamites gigas*, 528.
Bermuda Islands, Changes of Level in the, 92.
Blake, J. F., On some Superficial Deposits in Cutch, 141; On *Acanthonautilus bispinosus*, 287; The Laccolites of Cutch, 331.
Bonmahon, Waterford, The Red Rocks near, 188.
Bonney, T. G., On an "Ovenstone" from Zinal, Canton Valais, 110; On Foreign Boulders in the Chalk, 238; Rock-Specimens from Kimberley, South Africa, 448, 497.
Borneo, Fossils from the Sarawak River Limestones of, 407.
Boulders of Granite from the Middle Chalk of Bletchworth, 143.
Bracklesham Clay, Microzoa from the, 226.
Brazil, Fossil Entomostraca from, 195.
Brend, W. A., Lakes of Caernarvonshire, 404.
British Association for the Advancement of Science, 457, 465, 513.
British Geological Photographs, 31, 62, 109.
Brodie, Rev. P. B., Life of, 481; death of, 576.
Buckman, S. S., Deposits of the Bajocian in the North Cotteswolds, 376.

CAERNARVONSHIRE, Notes on some of the Lakes of, 404.
Callaway, C., Origin of some of the Gneisses of Anglesey, 237 ; Origin of the Grey Gneiss of Anglesey, 377.
Canada, Geological Survey of, 519–521.
Carboniferous Lamellibranchiata, 94.
Carboniferous Limestone, Ireland, New *Nautilus*-like Shell from, 147.
Carboniferous Limestone in North Wales, Range of Species in, 132.
Carboniferous Rocks, General Sequence of the, 144.
Carboniferous Rocks, Life-Zones in the British, 556.
Carboniferous Series in Great Britain, and True Position of Yoredale Beds, 159, 205.
Carriacou and the Agricultural Chemistry of Cacao, 419.
Carter, J., On the Decapod Crustacea of England, 571.
Catalogue of Fossil Cephalopoda, 280.
Catalogue of Geological Bibliographies, 233.
Causeways, Low-tide, 361.
Central Africa, Volcanic Activity in, 188.
Cephalopoda, Catalogue of the Fossil, 280.
Ceraterpeton Galvani, from the Coal-measures of Castlecomer, 293.
Ceratodus Kannemeyeri, Seeley, sp. nov., 543.
Chalk, Foreign Boulders in the, 169.
Chalky Boulder-clay and Glacial Phenomena, 485.
Chapman, F., On Microzoa in the Bracklesham Clay, 226.
Chemical Geology, 178.
Clava, Section at, 27, 63.
Claxheugh Section, Explanation of the, 377.
Cleeve Hill Plateau, 376.
Clowes, F., Detection and Measurement of Inflammable Gas and Vapour in the Air, 88.
Coal, a new Explanation of its Formation, 143.
Coleman, A. P., Glacial and Interglacial Deposits at Toronto, 515.
Cooke, J. H., New Section in the Middle Lias of Lincoln, 253.
Cope, Prof. E. D., Obituary of, 240.
Crick, G. C., On *Acanthoteuthis speciosa*, 1.
Croll's Life and Work, 71.
Crosby, W. O., The Pleistocene Ice-sheet in North America, 319.
Cross, Rev. J. E., Obituary of, 192.
Crystalline Gneisses, portions of the Original Earth's Crust, 537.
Cycad, New Fossil, from the Isle of Portland, 313.
Cycadeoidea gigantea from Portland, 46.
Cycadeoidea gigantea, Seward, an omission, 190.

DAVISON, C., The Great Japanese Earthquake of 1891, 23; On the Pembroke Earthquakes of 1892–3, 92.
Dawson, Dr. George Mercer, Life of, 193.
Dawson, G. M., Annual Report of the Geological Survey of Canada, 80, 521.
Deeley, R. M., Erosive Power of Rivers and Glaciers, 388.
Diamond, Genesis of the, 367.
Diener, Carl, On Himalayan Fossils, 562.
Dinosaurs of North America, 38.
Diplograptidæ and Heteroprionidæ of the Scanian Beds, 277.
Draper, D., Occurrence of *Sigillaria* and *Glossopteris* in Triassic Beds of South Africa, 235.
Drift in Ireland, The Distribution of the, 288.
Drift Deposits of Eastern England, 123, 153.
Drift Phenomena of Puget Sound, 555.
Dry Lakes of Western Australia, 363.

EARTHQUAKE, Indications of, 93.
Earth's Crust, Crystalline Gneisses portions of the Original, 537.
Echinocystis and *Palæodiscus*, Silurian genera of Echinoidea, 90.
Eichstädt, Bavaria, *Acanthoteuthis speciosa* from, 1.
Elementary Palæontology, 46.
Elles, G. L., On the Subgenera *Petalograptus* and *Cephalograptus*, 140.
Eminent Living Geologists, 193, 481.
Englacial Drift, 319.
Entomostraca, Fossil, from Brazil, 195.
Entomostraca, Fossil, from South America, 259, 289.
Erosive Power of Rivers and Glaciers, 388.
Erratic Boulders and Foreign Stones in the Drift Deposits, 123, 153.
Estheria Aricensis, T. R. Jones, sp. nov., 264.
Estheria Mawsoni, T. R. Jones, sp. nov , 290.
Estheria Mawsoni, var., 291.
Estheriina, gen. nov., 197.

Estheriïna astartoides, T. R. Jones, sp. nov., 201.
Estheriïna Bresiliensis, T. R. Jones, sp. nov., 198.
Estheriïna expansa, T. R. Jones, sp. nov., 201.
Etheridge, R., Wheelton Hind's Carboniferous Lamellibranchiata, 94.
Ettingshausen, Dr. Constantin Baron von, Obituary of, 575.
European Fauna, On the Origin of the, 420, 468.
Evans, Sir John, Presidential Address at Canada, 457.
Exfoliation of Gneiss in Brazil, 130.

FAIRCHILD, Herman Le Roy, Glacial Geology of Western New York, 529.
Faults, Actual Direction of Movement of, 545.
Finland and Scandinavia, Surface Contour of, 353, 361.
Flow of Rocks, Preliminary Notice of some Experiments on the, 513.
Foord, A. H., On *Acanthonautilus bispinosus*, Carboniferous Limestone, Ireland, 147, 287.
Foord and Crick, Catalogue of the Fossil Cephalopoda, 280.
Foraminifera, Index to the Genera and Species of the, 87.
Foreign Boulders in the Chalk, 169, 238.
Forest-Bed on the Norfolk Coast, 480.
Fox-Strangways, Geology of the Manchester, Sheffield, and Lincolnshire Railway, 49.
Franks, Sir A. Wollaston, Obituary of, 428.
Franz Josef Land, Fossils and Rocks from, 378.
Freire de Andrade, On the Geology of Mozambique, 274.
Fresh-water Ostracods in the Lower Carboniferous of Ayrshire, 526.

GARDINER and Reynolds, Account of the Portraine Inlier, 334.
Gases enclosed in Crystalline Rocks and Minerals, 177.
Geikie, Sir A., Annual Report of the Geological Survey, 233; Ancient Volcanoes of Great Britain, 326, 371.
Geological Bibliographies, 233.
Geological Commission of the Cape of Good Hope, 524.
Geological Congress at St. Petersburg, 517.
Geological Map of the British Isles, 417.
Geological Photographs, 31, 62, 109.
Geological Reconnaissance of Province of Mozambique, 274.
Geological Society of London, 46, 89, 139, 180, 234, 285, 330, 375, 569.
Geological Survey, Retirement of Mr. Watts, 528.
Geological Survey of Canada, 80, 519, 520, 521.
Geological Survey of Maryland, 560.
Geologically Recent Origin of the Surface Contour of Scandinavia, 355, 361.
Geologist, A Western Australian, 385.
Geology, Textbook of, 329.
Geology of Africa, 179.
Geology of the Country around Liverpool, 563, 568.
Geology of the County of Waterford, 502.
Geology of Hazara, 304, 345.
Geology and Palæontology of Argentina, 4, 20.
Gibson, W., On the Geology of Africa, 179; Age of the Rand Beds, 548.
Glacial Geology of Western New York, 529.
Glacial Period, Another Possible Cause of the, 48, 89.
Glacial Phenomena of Palæozoic Age in the Varanger Fiord, 139.
Glacial Phenomena of the Western Midlands of England, 485.
Glaciation of North-Central Canada, 514.
Glaciation of Norway, 453.
Glacio-Marine Drifts of the Vale of Clwyd, 236.
Gneiss in Brazil, Exfoliation of, 130.
Goodchild, J. G., Geological Evidence regarding the Age of the Earth, 415.
Gosling, A., Volcanic Activity in Central Africa, 188.
Gravels and Associated Deposits at Newbury, 285.
"Great Submergence" Again, 27, 63, 143.
Gregory, J. W., On the Age of the Morte Slate Fossils, 59, 191; On the Affinities of the Echinothuridæ, 90; On *Echinocystis* and *Palæodiscus*, 90; "Trespassers, Beware!" 427.
Gresley, W. S., On Coal, 143.
Grey Gneiss of Anglesey, The Origin of the, 377.

HANDLEY'S Pit, List of Fossils from, 258.
Hapalocrinus Victoriæ, Bather, sp. nov., 337.
Harris, G. F., Catalogue of the Tertiary Mollusca, 278.
Harrison, J. B., The Rocks and Soils of Grenada, 419.

Harrison, W. J., Textbook of Geology, 329.
Haughton, Rev. Prof., Obituary of, 573.
Hicks, H., Subdivisions of the Carboniferous Series in Great Britain, 91; The Age of the Morte Slate Fossils, 105; Morte Slate and Associated Beds in North Devon and West Somerset, 236.
High-level Shelly Clays and Mr. Mellard Reade, 189.
Hill, E., Low-tide Causeways, 361.
Himalayan Fossils, 562.
Himalayas, The Gneissose-Granite of the, 304, 345.
Hind, Wheelton, On the General Sequence of the Carboniferous Rocks, 144; Subdivisions of the Carboniferous Series in Great Britain, 159, 205.
Holland, T. H., On Augite-Diorites with Micropegmatite, 330.
Holm, Gerhard, On *Baltoceras*, gen. nov., 251.
Hornblende-Picrite from the Zmutthal, 202.
Howorth, Sir H. H., On the Erratic Boulders, etc., in the Drift of Eastern England, 123, 153; Water *versus* Ice as an Explanation of the Surface Beds of Eastern England, 213; The Surface Contour of Scandinavia and Finland, 355, 361.
Hull, E., Another Possible Cause of the Glacial Period, 48, 89; Sir Henry Howorth and the Glaciation of Norway, 453; Scandinavian Ice and Norfolk Drift, 572.
Hume, W. F., The Cretaceous Strata of County Antrim, 332.
Hunt, A. R., Foreign Boulders in the Chalk, 239.
Hunter, Rev. Robert, Obituary of, 382.
Hutchinson, H. N., Prehistoric Man and Beast, 77.

IGNEOUS Magmas, Differentiation in, 553.
Igneous Rocks in North Pembrokeshire, 334.
Indications of Earthquakes, 93.
Inflammable Gas and Vapour in the Air, 88.
International Geological Congress, 517.

JAPANESE Earthquake of 1891, Effect of, 23.
Johnston, W. and A. K., Geological Map of the British Isles, 417.
Johnston-Lavis, H. J., On the Chemical Name for H_2O, 526.
Jones, T. R., Fossil Entomostraca from Brazil, 195; Fossil Entomostraca from South America, 259, 289.
Judd, J. W., On William Smith's Manuscript Maps, 439.

KAYSER, E., Notes on Volcanic Bombs, 91.
Keisley Limestone, The Fauna of the, 47.
Kilkenny, New Specimen of *Ceraterpeton Galvani* from, 293.
Kilroe, J. R., On the Distribution of the Drift in Ireland, 288.
Kimberley, Rock-Specimens from, 448, 497.

LACCOLITES of Cutch, 331.
Lake, Philip, On the Actual Direction of Movement in Faults, 545.
Lakes of Caernarvonshire, Notes on some of the, 404.
Laurentian System, Structure and Origin of certain Rocks of the, 516.
Lewis, H. Carvill, Genesis of the Diamond, 367.
Life of the Rev. P. B. Brodie, 481.
Life and Work of Dr. Croll, 71.
Life-Zones in the British Carboniferous Rocks, 47, 556.
Lincoln, New Section in the Middle Lias of, 253.
List of Papers read in Section C (Geology), British Association Meeting at Toronto, 465.
Lobley, J. L., On the Depth of the Source of Lava, 189.
Lomas, J., Are Crystalline Gneisses portions of the Original Earth's Crust? 537.
Low-tide Causeways, 361.
Lundgren, Dr. Bernhard, Obituary of, 144, 431.
Lynchets, On the Origin of, 379.
Lyons, H. G., Note on the Nubian Desert South-East of Korosko, 237.

MADAGASCAR, A nearly complete Skeleton of *Æpyornis* from, 242.
Madreporarian Types of Corals, Systematic Study of, 170.
Manchester, Sheffield, and Lincolnshire Railway, Geology of, 49, 98.
Manuscript Maps by William Smith, 439.
Map of the Lake of the Woods, etc., 519.
Map of Trail Creek, British Columbia, 520.
Maps, New Geological Survey, 192.
Marine Animals, Distribution of, 265.

Marine Organisms and the Conditions of their Environment, 227.
Marr, J. E., Life-Zones in the British Carboniferous Rocks, 47; *Trinucleus seticornis* and the Upper Bala Beds, 378, 480.
Marsh, O. C., The Dinosaurs of North America, 38; On the Skull of *Protoceras*, 433.
Martin, E. A., Foreign Boulders in the Chalk, 169.
Maryland Geological Survey, 560.
Matthews, G. F., The Oldest *Siphonotreta*, 68.
McMahon, C. A., Notes on Volcanic and other Rocks which occur between Chaman and Persia, 234; On the Age of the Gneissose-Granite of the Himalayas, 304, 345.
Memoir of William Pengelly, 557.
Mesosaurian Reptile from Brazil, 145.
Mesozoic Fauna from Borneo, 407.
Method of Determining Actual Direction of Movement in Faults, 545.
Microscopic Contents of a sample of Bracklesham Clay, 226.
Middle Lias of Lincoln, New Section in the, 253.
Millericrinus recubariensis from the Muschelkalk, 116.
Mineralogical Geology, 418.
Moissan, H., Chemical Geology, 178.
Mojsisovics, E., On Himalayan Fossils, 562.
Mollusca, Catalogue of Tertiary, 278.
Mollusca of the Chalk Rock, 286.
Morte Slate Fossils, Age of the, 59, 105, 191, 236.
Morton, G. H., On the Range of Species in Carboniferous Limestone in North Wales, 132; Geology of the Country around Liverpool, 565.
Murray, Dr. J., On Marine Organisms, 227.

NEWTON, R. B., On a Jurassic Lamellibranch from Borneo, 407.
Newton and Teall, A Collection of Rocks and Fossils from Franz Josef Land, 375.
New York, Glacial Geology of Western, 529.
Norway, The Glaciation of, 453.
Nubian Desert South-East of Korosko, Note on the, 237.

OBITUARIES of David Robertson, 94; Dr. Bernhard Lundgren, 144, 431; Prof. C. Tomlinson, 191; Rev. J. E. Cross, 192; Prof. E. D. Cope, 240; Rev. Robert Hunter, 382; Sir A. W. Franks, 428; Samuel Allport, 430; James Windoes, 527; Rev. Prof. Haughton, 573; Baron Von Ettingshausen, 575; Rev. P. B. Brodie, 576.
Observations on Ameghino's Notes on the Geology of Argentina, 20.
Ogilvie, M.. Microscopic and Systematic Study of Madreporarian Types of Fossil Corals, 170.
Ordovician Beds near Tramore, Fauna of, 502.
Orthoceratidæ, *Baltoceras*, a new genus of the Family, 251.
"Ovenstones" (Talcose-schist) from near Zinal, Canton Valais, 110.
Oxfordshire, Terraced Hill Slopes in North, 299.

PALÆOLITHIC Deposits at Hitchin and their Relation to the Glacial Epoch, 229.
Palæontographical Society, Publications of the, 134.
Palæontology of the Decapod Crustacea of England, 571.
Palæontology and Geology of Argentina, 4.
Parkinson, J., Igneous Rocks in North Pembrokeshire, 335.
Pedinothuria and *Elikodiadema*, new Subgenera of Echinoidea, 90.
Pembroke, Earthquakes of August, 1892, and November, 1893, 92.
Pengelly, William, A Memoir of, 557.
Petalograptus and *Cephalograptus*, Subgenera of *Diplograptus*, 140.
Plant-remains in the Triassic Rocks of South Africa, 235.
Pleistocene Plants from Casewick, Shacklewell, and Grays, 377.
Pleistocene Rubble Drift near Portslade, 302.
Pliosaur, On the Structure of the Skull of a, 92.
Portraine Inlier, Account of the, 334.
Prehistoric Man and Beast, 77.
President's Address to the British Association, 457.
Protoceras, The Skull of, 433.
Protosiphon Kempanum, new Subgenus and Species, 70.
Pyrotherium-beds, 568.

QUESTION of Nomenclature, 526.

RAISED Beaches and Glacial Deposits of the Varanger Fiord, 140.
Raisin, C. A., Nature and Origin of

Rauenthal Serpentine, 142: On the Hornblende-Picrite from Zmutthal, 202.
Rand Beds, Age of the, 548.
Range of Species in Carboniferous Limestone of North Wales, 132.
Reade, T. M., Exfoliation of Gneiss in Brazil, 130; The Great Submergence "Again," 143; The Glacio-Marine Drift of the Vale of Clwyd, 236.
Recent Volcanic Ash Bed, 336.
Reed, F. R. C., On the Fauna of the Keisley Limestone, 47: The Red Rock near Bonmahon, 188; *Trinucleus seticornis*, 427, 526; Notes on the Geology of County Waterford, 502.
Reid. C., Palæolithic Deposits at Hitchin, 229; Pleistocene Plants from Casewick, etc., 377.
Richards, E. P., On the Gravels and Associated Deposits at Newbury, 285.
Rivers and Glaciers, Erosion by, 388.
Robertson, David, Obituary of, 94.
Rock-Specimens from Kimberley, South Africa, 448, 497.
Rocks from the Tonga Islands, 151.
Rubble Drift, A Section of the Pleistocene, 302.

SCANDINAVIAN Ice and the Norfolk Drift, 572.
Scharff, R. T., Origin of the European Fauna, 420, 468.
Sclater, P. L., On the Distribution of Marine Animals, 265.
Scolocystis, *Echinocystis*, and *Lysocystis*, 381.
Seeley, H. G., On *Ceratodus Kannemeyeri*, 543.
Seismic Activity of the District adjoining the Japanese Earthquake, 23.
Serpentine, Rauenthal, Nature and Origin of, 142.
Seward, A. C., On a New Cycadean Stem from Portland, 46; On *Cycadeoidea gigantea*, 90, 313; On the Association of *Sigillaria* and *Glossopteris* in South Africa, 235; On *Bennettites*, *Williamsonia*, and *Zamites gigas*, 528.
Sherborn, C. D., Index to the Genera and Species of the Foraminifera, 87.
Silurian, Melbourne, New Crinoid from, 337.
Siphonotreta, The Oldest, 68.
Skull of *Protoceras*, 433.
Smith, J., Recent Volcanic Ash Bed, 336; Fresh-water Ostracods in the Carboniferous, 526.
Smith, William, Manuscript Maps, 439.
Source of Lava, On the Depth of the, 189.
Stebbing, W. P. D., Boulders of Granite from Bletchworth, 143.
Stereosternum tumidum, from San Paulo, Brazil, 145.
Strahan, A., Glacial Phenomena of Palæozoic Age in the Varanger Fiord, 139; The Raised Beaches of Varanger Fiord, 140.
Superficial Deposits in Cutch, 141.
Surface Beds of Eastern England, 213.

TALCOSE-SCHISTS from near Zinal, Canton Valais, 110.
Tarr, R. S., Changes of Level in the Bermuda Islands, 92.
Teall, J. J. H., Differentiation in Igneous Magmas, 552.
Teall and Newton, On a Collection of Rocks from the Tonga Islands, 151.
Telluride Deposits in Western Australia, 550.
Terraced Hill Slopes in North Oxfordshire, 299.
Tilden, W. A., Gases enclosed in Crystalline Rocks and Minerals, 177.
Tomlinson, Charles, Obituary of, 191.
Tonga Islands, Rocks from the, 151.
Törnquist, On the Diplograptidæ, 277.
Toronto, Glacial and Interglacial Deposits at, 515.
"Trespassers, Beware!" 427.
Trinucleus seticornis and the Upper Bala Beds, 378, 427, 480, 526.
Tyrrell, J. B., The Glaciation of North-Central Canada, 514.

VOLCANIC Bombs in the Schalsteins of Nassau, 91.
Volcanic Rocks which occur between Chaman and Persia, 234.

WALFORD, E. A., Terraced Hill Slopes in North Oxfordshire, 299.
Warren, S. H., Section of Rubble Drift near Portslade, 302.
Water *versus* Ice as an Explanation of the Surface Beds of Eastern England, 213.
Watts, W. W., On British Geological Photographs, 31, 62, 109; Retirement from the Geological Survey, 528.
Western Australian Geologist, 385.
Wheeler, W. H., On "Littoral Drift," 44.
Willis, Bayley, Drift Phenomena of Puget Sound, 555.
Windoes, James, Obituary of, 527.
Woods, H., Elementary Palæontology, Invertebrata, 46; The Mollusca of the Chalk Rock, 286.

Woodward, A. S., On Ameghino's "Notes on the Geology and Palæontology of Argentina," 20; On a New Specimen of *Stereosternum tumidum*, from San Paulo, Brazil, 145; On *Ceraterpeton Galvani* from Castlecomer, 293.

Woodward, H. B., Geology of the Manchester, Sheffield, and Lincolnshire Railway, 98; Chalky Boulder-clay and Glacial Phenomena of Western Midlands of England, 485.

Woodward, H. P., The Dry Lakes of Western Australia, 363; Biographical Notice of, 385; On the so-called Lode Formations of Hannans, Western Australia, 550.

Woolacott, D., Explanation of the Claxheugh Section, 377.

YOREDALE Series, True Position of the Beds mapped as the, 91, 159, 205.

ZMUTTHAL, On a Hornblende-Picrite from the, 202.

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